



Natural Sciences and Engineering
Research Council of Canada

200 Kent Street
Ottawa, Canada
K1A 1H5

Conseil de recherches en sciences
naturelles et en génie du Canada

200, rue Kent
Ottawa, Canada
K1A 1H5

STRATEGIC GRANTS IN ENERGY

LES SUBVENTIONS THÉMATIQUES EN ÉNERGIE

- **Summaries of New Research Projects**
Résumés de nouveaux projets de recherche
- **List of Ongoing Research Projects**
Liste de projets de recherche en cours
- **Summaries of Completed Projects**
Résumés de travaux de recherche terminés

1986-87

2100153

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FORWARD / AVANT-PROPOS

FOREWORD

The Natural Sciences and Engineering Research Council offers a program of strategic grants to initiate or accelerate research projects in areas of Canadian interest. The aim of the program is to enable university researchers to make greater contributions than in the past towards the understanding or solution of problems of national concern, either through specific applied research projects having potential for relatively short-term benefits, or through more basic research activities designed to develop knowledge in areas of potential importance. The total budget for the strategic grants program for 1986-87 is \$32 million.

In 1986-87 the strategic grants program addressed eight specific fields: 1) biotechnology, 2) communications and computers, 3) energy, 4) environmental toxicology, 5) food and agriculture, 6) industrial materials and processes, 7) oceans, and 8) open (which includes areas of national concern other than the seven identified fields).

Selection panels composed of recognized scientists and engineers from the university, industry and government sectors rate all proposals using the following criteria:

- scientific merit of the proposed research;
- excellence of the applicant(s);
- relevance of the proposed research to the field.

AVANT-PROPOS

Le Conseil de recherches en sciences naturelles et en génie offre un programme de subventions thématiques visant à lancer ou à accélérer des projets de recherche dans des domaines d'intérêt national. Le but de ces subventions est de permettre aux chercheurs universitaires de contribuer davantage à la compréhension et à la solution de problèmes d'intérêt national. Il peut s'agir de recherche appliquée pouvant s'avérer utile à court terme ou encore de recherche plus fondamentale destinée à augmenter la somme des connaissances dans des domaines d'intérêt national. Le budget total du programme en 1986-1987 est de 32 millions de dollars.

En 1986-1987, le programme de subventions thématiques comprenait huit domaines choisis: 1) l'alimentation et l'agriculture, 2) la biotechnologie, 3) l'énergie, 4) les matériaux et procédés industriels, 5) les océans, 6) le thème "ouvert" (regroupant des domaines d'intérêt national autres que les sept domaines choisis), 7) les télécommunications et l'informatique et enfin, 8) la toxicologie de l'environnement.

Des comités de sélection composés de scientifiques et d'ingénieurs reconnus provenant des secteurs universitaire, industriel et gouvernemental utilisent les critères suivants pour évaluer toutes les demandes:

- valeur scientifique de la recherche proposée;
- excellence des candidats;
- pertinence du projet par rapport au domaine désigné.

Each criterion carries equal weight. To be funded, an application must receive a high ranking under each of the three criteria. Regional considerations do not enter into the evaluation of proposals submitted under this program. The panels are responsible for deciding what is relevant to, and of priority within, the broad areas identified for support, consistent with the descriptions of the fields.

The strategic grants program contributes to the training of research manpower and encourages the transfer of technology to the user sector. This is the basis of its success. To facilitate this technology transfer, NSERC annually publishes booklets describing some of the research funded through the program. There is a separate booklet for each field; each one contains summaries of the new research projects funded as a result of the annual strategic grants competition, a list of all on-going projects funded by NSERC in the particular field, and summaries of strategic research projects completed in 1986, including references to publications arising from the NSERC-funded research. Further information on the research being supported by NSERC may be obtained by contacting the researcher directly, or the Strategic Grants Division at (613) 996-1597.

NSERC offers other opportunities for technology transfer under its university/industry program. Further information on this program or on any of NSERC's awards programs may be obtained by calling (613) 995-5992 or by writing:

4 NSERC
Communications Division
200 Kent Street
Ottawa, Ontario
K1A 1H5

Les comités doivent accorder une importance égale à chacun des critères. Pour obtenir une subvention, le projet doit recevoir une cote élevée en fonction de chacun des trois critères. Les considérations régionales ne doivent pas entrer en ligne de compte dans l'examen des demandes. Les comités ont la responsabilité de déterminer la pertinence des divers secteurs et leur priorité à l'intérieur de chaque domaine désigné, en se basant sur les descriptions des domaines.

Le programme de subventions thématiques contribue à former des chercheurs et donne lieu à un transfert de technologie au secteur des utilisateurs: voilà la base de son succès. Afin de faciliter le transfert de technologie, le CRSNG publie, chaque année, des livrets décrivant la recherche subventionnée dans le cadre de ce programme. Chaque domaine fait l'objet d'un livret séparé; on y retrouve un résumé des nouveaux projets de recherche subventionnés suite au concours annuel de subventions thématiques, une liste de tous les projets en cours dans le domaine en question subventionnés par le CRSNG et un résumé des projets de recherche thématique terminés en 1986, y compris des références aux publications découlant de la recherche subventionnée par le CRSNG. Des renseignements supplémentaires sur les projets de recherche appuyés par le Conseil peuvent être obtenus en communiquant avec le chercheur lui-même ou avec la division des subventions thématiques au (613) 996-1597.

Le CRSNG offre d'autres possibilités pour le transfert technologique grâce à son programme conjoint universités-industrie. Pour plus d'information sur ce programme ou sur les autres programmes du CRSNG, veuillez téléphoner au (613) 995-5992 ou vous adresser au:

CRSNG
Division des communications
200, rue Kent
Ottawa (Ontario)
K1A 1H5

FIELD DESCRIPTION / DESCRIPTION DU DOMAINE



ENERGY

In the field of Energy, strategic grants promote high-quality, mission-oriented energy research and development in Canadian universities.

The OBJECTIVE of the program is to help bridge the gap between basic research programs in universities and applied energy research and development programs in government and industry.

The BENEFITS of the program will be novel and more accessible energy information, an enhanced technical manpower base, and accelerated development of high technology in the energy field. New products, processes and improved energy efficiencies developed through this program should give Canadians a competitive edge in world markets.

PRIORITY will be given to university groups which seize opportunities and address needs relevant to the changing Canadian energy scene.

Both fundamental and applied research proposals are eligible; however, relevance to the field of energy must be clearly established in the submission. The following list of fields, which is not meant to be exclusive, indicates areas in which strategic grant proposals will be considered.

1. Energy Sources and Fuel Conversion

- Hydrocarbons and carbonaceous fuels (recovery, refining, liquefaction, gasification, etc.)
- Nuclear fuels
- Hydrogen as a fuel
- Wood and biomass
- Photochemical processes

2. Energy and Power Production Systems

- Combustion and fuel cells
- Heat engines and heat pumps
- Fission and fusion technologies
- Solar systems (thermal and photoelectric)
- Other renewable (wind, hydraulic, tidal, geothermal)
- Other renewables

3. Energy Transmission and Storage

- Electricity transmission
- Pipeline and other fuel transport technologies
- Physical, chemical, and mechanical storage (batteries, pump storage, etc.)
- Storage of hydrogen and hydrocarbons (tanks for CNG, H₂, etc.)

4. Energy Conservation and End-Use

- Efficient home building, heating, and lighting
- Heat recovery systems
- Energy efficient machinery and processes (motors, control systems, etc.)
- Transportation systems

L'ÉNERGIE

Dans le domaine de l'énergie, les subventions thématiques favorisent au sein des universités canadiennes des projets de recherche et développement orientés de haute qualité.

L'OBJECTIF est d'aider à combler l'écart entre les programmes de recherche fondamentale des universités et les programmes de recherche et de développement appliqués du gouvernement et de l'industrie.

Les AVANTAGES: des informations originales et plus accessibles, une main-d'oeuvre spécialisée plus compétente et un développement accéléré de la haute technologie en matière d'énergie. Les produits et les procédés nouveaux et les moyens plus efficaces d'utilisation de l'énergie mis au point grâce à ce programme devraient permettre aux Canadiens d'être plus compétitifs sur les marchés mondiaux.

On accordera la PRIORITÉ aux groupes de chercheurs universitaires qui s'attaquent à des problèmes pertinents et répondent aux besoins de la situation énergétique canadienne en évolution constante.

Les projets de recherche fondamentale et de recherche appliquée sont admissibles, mais leur pertinence par rapport au domaine de l'énergie doit être clairement établie dans la demande. Voici une liste (non exhaustive) de domaines qui peuvent faire l'objet de demandes de subventions thématiques.

1. Sources d'énergie et conversion du combustible

- Hydrocarbures et combustibles carbonés (récupération, raffinage, liquéfaction, gazéification, etc.)
- Combustibles nucléaires
- Hydrogène (comme combustible)
- Bois et biomasse
- Procédés photochimiques

2. Procédés de production d'énergie et d'électricité

- Combustion et piles à combustible
- Machines thermiques et thermopompes
- Technologies de la fission et de la fusion
- Systèmes solaires (thermiques et photoélectriques)
- Énergie renouvelable (éolienne, hydraulique, marémotrice, géothermique)
- Autres genres d'énergie renouvelable

3. Transmission et stockage de l'énergie

- Transmission de l'électricité
- Pipelines et autres techniques de transport du combustible
- Stockage physique, chimique et mécanique (batteries, pompes, etc.)
- Stockage de l'hydrogène et des hydrocarbures (réservoirs de CNG, H₂, etc.)

4. Conservation et consommation de l'énergie

- Construction domiciliaire, chauffage et éclairage efficaces
- Méthodes de récupération de la chaleur
- Procédés et machinerie efficaces (moteurs, systèmes de contrôle, etc.)
- Systèmes de transport

Subsections common to all of the above categories are modelling and analysis, by-product and waste-product management, and environmental concerns.

Self-sufficiency and the net energy saved or produced are important factors in the selection process. Proposals addressing short-, medium-, or long-term objectives are welcome but all applications must present a time-frame for implementation of the proposed technology.

February 1986

La modélisation et l'analyse, la gestion des sous-produits et des déchets, ainsi que les considérations environnementales sont des subdivisions communes à toutes les catégories susmentionnées.

On doit noter que l'autosuffisance et la quantité nette d'énergie économisée ou produite sont des facteurs importants lors de la sélection. Les propositions décrivant des objectifs à court, moyen ou long terme sont admissibles, mais toutes les demandes doivent présenter un échéancier de mise en oeuvre de la technologie proposée.

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LIST OF NEW PROJECTS / LISTE DES NOUVEAUX PROJETS

Energy / Énergie

Name/Nom Department/Département University/Université	Title/Titre	\$*	Page
<u>1. Energy Conservation/ Conservation de l'énergie</u>			
Malik, O.P. Electrical Eng. Calgary	Microcomputer based adaptive stabilizer for an electric generating unit * with G.S. Hope (Calgary)	112,500	28
Sislian, J.P. Aerospace Studies Toronto	Experimental and theoretical investigation of practical gas turbine combustor flows	132,300	34
<u>2. Energy Conversion and Storage/ Conversion et stockage de l'énergie</u>			
Conway, B.E. Chemistry Ottawa	Preparation and evaluation of electrocatalysts for water electrolysis and H ₂ /O ₂ fuel cells	244,670	18
<u>3. Energy Transportation and Distribution/ Transport et distribution de l'énergie</u>			
El-Hawary, M.E. Electrical Eng. TUNS	Optimal load flow and planning models for hydro-thermal electric energy systems	114,000	20
Ferland, J.A. Infor. & rech opér. Montréal	Planification de la production et des équipements de production et distribution de l'énergie hydro-électrique * avec R.Cléroux (Montréal), A.Turgeon (McGill), G.Côté, L.Lafond (Hydro-Qué.)	123,000	21
Venart, J.E.S. Mechanical Eng. New Brunswick	Pressure liquified fuel tank thermal response (continuation) * with A.C. Mendes de Sousa, F.R. Steward (New Brunswick)	25,000	39
<u>4. Fossil Fuels/ Combustibles fossiles</u>			
Costerton, J.W. Biology Calgary	Development of a battery of formation-plugging bacterial spores to enhance primary and secondary oil recovery	210,000	19

* Total funds committed/Montant total accordé

Energy / Énergie

Name/Nom Department/Département University/Université	Title/Titre	\$*	Page
4. <u>Fossil Fuels/</u> <u>Combustibles fossiles</u>			
Fritz, P. Earth Sciences Waterloo	Isotope geochemistry of hydrocarbons in crystalline rocks * with S.K.Frape(Waterloo) J.A.Welham, S.A.Macko(Memorial)	114,500	22
Jull, E.V. Electrical Eng. British Columbia	Modelling of seismic pulse diffraction by planar structures with edges * with M.J.Yedlin (UBC)	126,880	24
Laskowski, J.S. Min./Min. Proc. British Columbia	Rheology of the magnetite heavy medium suspensions * with A.L. Mular (UBC)	133,632	27
Neumann, A.W. Mechanical Eng. Toronto	Bacterial desulphurization of coal * with D.R. Absolom (Toronto)	125,308	30
Ozin, G.A. Chemistry Toronto	Alkane activation by intrazeolite organometallics	183,000	31
Pritchard, H.O. Chemistry York	Improving the detonability of diesel fuels	83,000	32
Silveston, P.L. Chemical Eng. Waterloo	Synthetic coke and metallurgical carbon from coal char.	75,860	33
Smy, P.R. Electrical Eng. Alberta	The use of electrically induced turbulence in combustion	177,000	36
Steward, F.R. Chemical Eng. New Brunswick	Combustion and retorting properties of New Brunswick oil shale * with D. Karman (UNB)	62,710	37
Walker, R.G. Geology McMaster	Origin of reservoir sandstones and conglomerates, Alberta	159,150	40

* Total funds committed/Montant total accordé

Energy/Énergie

Name/Non Department/Département University/Université	Title/Titre	\$*	Page
5. <u>Nuclear Energy/</u> <u>Énergie nucléaire</u>			
Capjack, C.E. Electrical Eng. Alberta	Computer simulation for laser-plasma interaction experiments * with R. Marchard (Alberta)	134,700	17
Gregory, B.C. INRS-Énergie Univ. du Québec	Nouveaux détecteurs pour les diagnostics du plasma d'un tokamak * avec B.Boucher, J.M.Larsen, B.L.Stansfield, B.Terreault, W.W.Zuzak (INRS)	148,000	23
Measday, D.F. Physics British Columbia	Muon catalyzed fusion * with M. Saloman (TRIUMF)	71,340	29
Smeltzer, W.W. Materials Sci. McMaster	Tritium diffusion and permeation barrier technology * with D.A.Thompson, J.S.Kirkaldy (McMaster)	150,000	35
6. <u>Renewable resources /</u> <u>Ressources renouvelables</u>			
Krakow, K. Mechanical Eng. Concordia	Defrosting and frosting of heat pumps in cold climates * with S. Lin (Concordia)	162,880	25
Langford, C.H. Chemistry Concordia	Molecular photovoltaic cells * with D. Gravel (Montreal) J.P. Dodelet (INRS)	210,000	26
Tong, B.Y. Physics Western Ontario	Amorphous silicon thin film tandem solar cells * with P.K. John, S.K. Wong (UWO)	223,500	38

* Total funds committed/Montant total accordé

SUMMARIES OF NEW PROJECTS / RÉSUMÉS DES NOUVEAUX PROJETS

SUMMARY FOR PUBLICATION/RÉSUMÉ À PUBLIER

FIELD OF RESEARCH / DOMAINE DE RECHERCHE

(Check one/cocher la case appropriée)

- | | | | |
|---|--|---|--|
| ☐ Biotechnology /
Biotechnologie | ☐ Communications and Computers /
Télécommunications et informatique | ☒ Energy /
Énergie | ☐ Environmental Toxicology/
Toxicologie de l'environnement |
| ☐ Food-Agriculture /
Alimentation-Agriculture | ☐ Industrial Materials and Processes /
Matériaux et procédés industriels | ☐ Oceans /
Océans | ☐ Open /
Ouvert |

Name/Nom: Dr. C.E. Capjack

Department/Département: Electrical Engineering

University/Université: University of Alberta

Phone number (optional)/N° de téléphone (facultatif): (403) 432-3379 (CAPJACK), (403) 432-5357 (MARCHAND)

Title of Project/Titre du projet: Computer Simulation for Laser-Plasma Interaction Experiments

The research program involves the development and application of magneto-hydrodynamic simulation codes for the support of experiments designed to establish the feasibility of laser driven inertial fusion. Equal emphasis is to be placed on providing computational support for experiments and on the continued evolution of the simulation codes (so that these reflect the current understanding of plasma behavior).

The MEDUSA code is a one-dimensional plasma hydrodynamic code which will be used to model experiments in which x-ray generation and transport processes play an important role in determining the plasma behavior. These effects are particularly important at short wavelengths, such as in the KrF laser heated foil experiments at the University of Alberta and the frequency quadrupled experiments at the National Research Council. MEDUSA will be used to infer experimentally determined quantities (such as the time for the laser to burn through the target and the measured x-ray emission) and to predict physical parameters such as the density, temperature, pressure, expansion velocity and heat flow.

The 2-D Eulerian code CASTOR and the 2-D Lagrangian code SALE will be used to simulate experiments in which two-dimensional effects influence the propagation of the laser beam and the time and spatial evolution of the plasma. Included in this category are experiments in which small laser spot sizes or where relatively long duration laser pulses are used. The SALE code is being developed to model high laser intensity experiments in which strong shocks and large fluid deformations occur. SALE will also enable more complicated laser targets (eg. layered) to be studied. The above problems are best described by a Lagrangian code.

The principal objective of this project is to develop and use computer simulation codes to provide computational support for current and future planned experiments involving inertial fusion research in Canadian laboratories.

SUMMARY FOR PUBLICATION/RÉSUMÉ À PUBLIER

FIELD OF RESEARCH / DOMAINE DE RECHERCHE

(Check one/cocher la case appropriée)

☐ Biotechnology /
Biotechnologie

☐ Communications and Computers /
Télécommunications et informatique

☒ Energy /
Énergie

☐ Environmental Toxicology
Toxicologie de l'environnement

☐ Food-Agriculture /
Alimentation-Agriculture

☐ Industrial Materials and Processes /
Matériaux et procédés industriels

☐ Oceans /
Océans

☐ Open /
Ouvert

Name/Nom: B.E. Conway

Department/Département: Chemistry

University/Université: of Ottawa

Phone number (optional)/N° de téléphone (facultatif): 564-2431/2430

Title of Project/Titre du projet: Preparation and Evaluation of Electrocatalysts for Water
Electrolysis and H₂/O₂ Fuel Cells

The Canadian hydrogen energy programme is concerned, amongst other matters, with economic production of hydrogen, substantially by the route of electrolysis of water bearing in mind our extensive hydro facilities and natural water power.

Work will be carried out on development and evaluation of a variety of metal alloy or metal mixture electrocatalysts for cathode materials and of mixed or doped oxides for anode materials. Emphasis will be placed on materials suitable for alkaline water electrolyzers and alkaline solution fuel cells.

Electrochemical and physical evaluation of the materials will be made by computer-controlled polarization measurements coupled with evaluation of the adsorptive and electrocatalytic behavior of electrodes by means of a recently developed method based on potential relaxation transients.

Long term stability and corrosion aspects of the performance of electrodes will also be addressed in relation to transfer of suitable materials for commercial application and development.

SUMMARY FOR PUBLICATION/RÉSUMÉ À PUBLIER

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(Check one/cocher la case appropriée)

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Toxicologie de l'environnement |
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Alimentation-Agriculture | ☐ Industrial Materials and Processes /
Matériaux et procédés industriels | ☐ Oceans /
Océans | ☐ Open /
Ouvert |

Name/Nom: J. WILLIAM COSTERTON

Department/Département: Biology

University/Université: University of Calgary

Phone number (optional)/N° de téléphone (facultatif): (403) 220-7301/3545

Title of Project/Titre du projet: Development of a battery of formation-plugging bacterial spores to enhance primary and secondary oil recovery.

When a production well is drilled into reservoir rock containing oil in its pore spaces, and it is perforated to make contact with this "pay zone", oil usually flows into the well because of pressure within the formation. This primary recovery yields an average of 15% of the oil in place and then the reservoir pressure must be re-established by the injection of water into injection wells under pressure to recover a further $\pm$ 15% of the oil in place in this secondary recovery procedure. This ideal scenario is often inoperative because of unfortunate characteristics of the oil or of the rock formation in question, and several difficulties are prominent in Western Canadian oil recovery operations. In the heavy oil reservoirs of the Alberta-Saskatchewan border, the pay zone often overlies a rock zone containing water, and because the water moves much more easily through the pore spaces than the very heavy viscous oil, this fluid forms an ascending cone and the well eventually produces only water. Reservoir experts are agreed that the reduction of the permeability of the rock in a radial "pad" at the oil-water interface within the formation would preclude this coning of the underlying water. In most of the secondary waterflood recovery operations in Western Canada, reservoir engineers are plagued with differential permeability, in that injected water flows preferentially in high permeability channels, and oil recovery comes to a halt when injected water simply appears at the production well without having displaced any oil. These experts are agreed that the selective plugging of these high permeability water channels will force the injected water into unswept zones and thus recover additional oil at very little additional expense.

Living (vegetative) bacterial cells are presently being used to reduce the permeability of high permeability water breakthrough channels in oilfields in both Texas and California, but success is only partial because these cells quickly adhere to rock surfaces near the injection well and produce a shallow plugging that can be bypassed so that water reenters the high permeability zones. Interface "pads" to prevent coning cannot be produced by these shallow plugging methods. Both spores and starved ultramicrocells are dormant non-adherent cell forms that can move deep into the pore spaces of rock (40 m has been demonstrated) and can subsequently be stimulated by nutrients to induce cellular growth and the production of plugging polymers. Using both AOSTRA and NSERC (Strategic) support, we will develop a battery of ultramicrocells and spores that are suitable for the range of permeability, salinity and temperature conditions found in Western Canadian oilfields and we will develop nutrient stimulation packages and large scale cell production procedures to take these strains into the field in the third year of this proposed study.

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Alimentation-Agriculture | ☐ Industrial Materials and Processes /
Matériaux et procédés industriels | ☐ Oceans /
Océans | ☐ Open /
Ouvert |

Name/Nom: M.E. El-Hawary

Department/Département: Electrical Engineering

University/Université: Technical University of Nova Scotia

Phone number (optional)/N° de téléphone (facultatif): (902) 429-8300, Ext.2191

Title of Project/Titre du projet: Optimal Load Flow and Planning Models for Hydro-Thermal Electric Energy Systems.

Operating an electric power system at the lowest possible cost, while maintaining a safe and secure delivery of power, has been an area of continuing interest to electric utilities, their customers and regulatory agencies since the early days of interconnected grids. Present day utilities rely on energy control centers that perform routinely functions of allocation, operations, and control through complex computer software.

The first part of research to be carried out in this project considers the problem of representing the short term optimal economic operation studies in a manner that is suited for use in long range expansion planning studies. This part leads to better techniques for predicting energy production costs resulting from the best available mode of operation of alternatives for use in planning contemplated utility's expansions.

The second part of this research project involves evaluating the various possible means of achieving the best mode of operation under conflicting goals. This aspect is important in reconciling economics considerations with security and environmental aspects in the day-to-day operation of an electric utility system.

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Alimentation-Agriculture | ☐ Industrial Materials and Processes
Matériaux et procédés industriels | ☐ Oceans
Océans | ☐ Open
Ouvert |

Name/Nom: Jacques A. Ferland

Department/Département: Informatique et recherche opérationnelle

University/Université: Université de Montréal

Phone number (optional)/N° de téléphone (facultatif): 514-343-7474

Title of Project/Titre du projet: Planification de la production et des équipements de production et distribution de l'énergie hydro-électrique.

Le but de ce projet est de favoriser la création d'une équipe de recherche sur les problèmes de planification et de gestion dans le domaine de l'énergie électrique. Nous voulons mettre à la disposition des gestionnaires des logiciels interactifs qui seront pour eux des outils utiles et efficaces dans la gestion et la planification de l'énergie. Les problèmes spécifiques que nous comptons aborder sont reliés à la planification des installations de production et à leur gestion, de même qu'à la distribution de l'énergie produite.

De façon générale, chaque projet spécifique est abordé selon la méthodologie suivante:

- i) Analyse du problème et élaboration d'un modèle mathématique.
- ii) Analyse des méthodes de résolution déjà proposées dans la littérature et développement de la méthode algorithmique retenue.
- iii) Développement d'un logiciel informatique pour implanter la méthode algorithmique.
- iv) Intégration du logiciel dans un système interactif facile d'utilisation pour manipuler les données, pour lancer l'exécution et pour analyser les résultats.

La mise sur pied de cette équipe de recherche favorisera l'établissement et la consolidation de liens avec des organismes canadiens d'énergie électrique qui pourront, d'une part nous apporter des problèmes intéressants que leur priorités journalières ne leur permettent pas d'analyser et, d'autre part, profiter de l'expertise de l'équipe.

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| ☐ Food-Agriculture /
Alimentation-Agriculture | ☐ Industrial Materials and Processes /
Matériaux et procédés industriels | ☐ Oceans /
Océans | ☐ Open /
Ouvert |

Name/Nom: P. Fritz

Department/Département: Department of Earth Sciences

University/Université: University of Waterloo

Phone number (optional)/N° de téléphone (facultatif): (519) 885-1211, Ext. 3236

Title of Project/Titre du projet: Isotope Geochemistry of Hydrocarbons in Crystalline Rocks.

Methane and higher hydrocarbons occur as "natural gas" in the majority of operating mines on the Canadian Shield. In a preceding study the applicants documented the regional distribution of these gases and showed that they are produced within the crystalline rock of the Canadian Shield. Amounts encountered are variable but a small borehole in Thompson (Manitoba) discharged in 1985 about 53,000 m³/year. This proposal is made because, although the applicants documented the abiotic nature of methane genesis in these environments, it was not possible to engage into detailed studies which would permit a comprehensive description of the geochemical environments. These must be known, however, before statements about crustal migration and accumulations into economic deposits can be made. The project would involve sampling at at least three mining districts, a comprehensive package of chemical and isotopic analyses and determination of geochemistry and isotope content of associated gases and fluids. In this context it is noteworthy that the previous study provided evidence for the presence of up to 30% free hydrogen in these gases. Such observations are significant for deep waste disposal programmes.

P. Fritz and S.K. Frappe, Earth Sciences, Univ. of Waterloo, Waterloo, Ont.

J. A. Welhan and S. Macko, Earth Sciences, Memorial Univ., St. John's, Nfld.

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Name/Nom: GREGORY, Brian Charles

Department/Département: INRS-Energie

University/Université: du Québec

Phone number (optional)/N° de téléphone (facultatif): (514) 468-7700

Title of Project/Titre du projet: Nouveaux détecteurs pour les diagnostics du plasma d'un tokamak

Ce programme de recherche se divise en 3 projets: A, le développement des sondes simples pour l'hydrogène atomique; B, le développement d'un détecteur matriciel dans le visible du type intensificateur d'image pour un diagnostic de fluorescence; et C, le développement d'un détecteur matriciel dans l'ultra-violet lointain avec résolution améliorée pour la spectroscopie. Les trois projets seront poursuivis pour améliorer les systèmes de mesures du Tokamak de Varennes dans le cadre général de la fusion thermonucléaire contrôlée. Le développement des sondes de l'hydrogène vise l'amélioration de la connaissance des flux d'hydrogène sur les différentes surfaces autour du plasma du tokamak. Ceci est important pour connaître la provenance d'impuretés qui entrent dans le plasma et qui le contaminent. Ces sondes peuvent avoir d'autres applications où l'on veut mesurer un flux d'hydrogène. Le détecteur matriciel associé avec la fluorescence induite par laser fournira la possibilité de mesurer simultanément le profil spatial de lumière émise par fluorescence dans le plasma de bord du tokamak. La fluorescence est un diagnostic puissant pour faire des mesures locales de certains paramètres dans un plasma (la densité et la température (vitesse) des atomes ou ions). On peut aussi mesurer la densité électronique, la densité des niveaux excités des atomes (ou ions), et le champ électrique dans le plasma. La résolution temporelle de ce diagnostic est l'ordre de 1 μ m (ou moins) et la résolution spatiale et de l'ordre de cm^3 (possiblement moins). Le détecteur matriciel à résolution améliorée sera développé pour la spectroscopie du plasma du tokamak. Il permettra la connaissance de la température ionique et les concentrations des diverses impuretés pendant toute la durée du plasma, mesure impossible actuellement. Ces détecteurs peuvent être rendus sensibles à d'autres radiations (photons, X, particules chargées) et donc trouveront des applications ailleurs en recherche scientifique, en médecine, en industrie et militaire.

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Name/Nom: Edward V. Jull

Department/Département: Electrical Engineering

University/Université: British Columbia

Phone number (optional)/N° de téléphone (facultatif): (604)228-3282

Title of Project/Titre du projet: MODELLING OF SEISMIC PULSE DIFFRACTION BY PLANAR
STRUCTURES WITH EDGES

An efficient and accurate method of calculating acoustic pulse scattering by planar structures with edges has been developed. It uses asymptotic expressions from rigorous electromagnetic diffraction theory together with computer algorithms for seismic modelling. This will form the basis of numerical models for seismic pulse diffraction by more complicated geophysical structures. The numerical models will be verified by acoustic measurements from a physical modelling facility which will be built from funds provided by ESSO Canada.

Numerical and physical modelling of seismic pulse diffraction is important in the interpretation of recorded data in hydrocarbon exploration and location. The techniques developed in this work may also find application in other areas in which electromagnetic and acoustic waves are used, such as remote sensing with radar and sonar.

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Name/Nom: Prof. K. Krakow

Department/Département: Mechanical Engineering

University/Université: Concordia University

Phone number (optional)/N° de téléphone (facultatif): (514) 848-3140

Title of Project/Titre du projet: Defrosting and Frosting of Heat Pumps in Cold Climates

The objective of the proposed research is to do a comprehensive study of heat pump defrosting cycles in light of the recent development of variable speed compressors and electrically controlled expansion valves. Numerical (computer) models of a heat pump that will determine the performance, for both defrosting and frosting operating modes, for specified capacities of the evaporator, condenser, compressor, and throttling device, will be developed. Analytical models of the thermodynamic cycles for defrosting by reversing the cycle and by hot gas will be developed. These models should be useful in determining optimum defrosting strategies and sizing the components and piping of heat pumps. The analytical models of the defrosting cycles will be quasi-static models in order to account for the heat capacity of the coil and frost. An analytical model of an outdoor unit being defrosted will also be developed. The frosting process will also be investigated. An analytical model of an outdoor coil serving as an evaporator (cooling and dehumidifying) with wet and frosted surface conditions will be developed. The analytical models will be incorporated in computer programs. Data required to validate the analytical models will be determined by experimental investigations. Our current heat pump will be modified to include a variable speed compressor and a reversible electrically controlled expansion valve. A comprehensive study of the refrigerant charge in systems will be made. Analytical methods for determining the critical refrigerant charge required for a specified heat pump operating condition will be made. The operation of heat pumps with and without receivers will be investigated. All investigations and analysis will consider possible advantages enabled by the use of variable speed compressors and electrically controlled expansion valves. The results of this project will contribute to the design of more effective heat pumps for cold climates.

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Name/Nom: C.H. LANGFORD

Department/Département: Chemistry

University/Université: CONCORDIA

Phone number (optional)/N° de téléphone (facultatif): (514) 848-3342

Title of Project/Titre du projet: MOLECULAR PHOTOVOLTAIC CELLS

Using a new concept of charge separation deep within a layer of mixed molecular semiconductors called "multiple microjunctions", a scheme is under development to fabricate two (2) types of efficient photovoltaic cells using inexpensive, non-crystalline molecular dyes. One type is a "dry" cell with a contact via a conducting polymer layer. The other is a "wet" electrochemically coupled cell using an ion exchange polymer. The dyes include novel soluble phthalocyanines which can form amorphous or crystalline phases according to variation of conditions.

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Name/Nom: LASKOWSKI, J.S.

Department/Département: Mining and Mineral Process Engineering

University/Université: The University of British Columbia

Phone number (optional)/N° de téléphone (facultatif): (604) 228-4949

Title of Project/Titre du projet:

RHEOLOGY OF THE MAGNETITE HEAVY MEDIUM SUSPENSIONS USED IN COAL-WASHING PLANTS

In Western Canada, which supplies almost 90% of Canadian coal production, more than 50% of the washed coal is cleaned in an aqueous suspension of finely ground magnetite. The density of such a suspension must be in the range of 1.5 to 1.9 g/cm³ and is referred to as a heavy medium.

Sixteen million tonnes of coal exported from Canada in 1982 were cleaned in magnetite heavy media. This production required approx. 50,000 tonnes of magnetite costing about \$ 3 million. In addition a further 25,000 tonnes of Canadian magnetite were exported to Australia and USA (estimated revenue for Canada was 1.8 million) in 1982.

The heavy medium viscosity (rheology) and stability, determined by magnetite concentration, particle size distribution and particle-particle interactions, define the sharpness of separation of coal from gangue particles. Ideally the medium should be characterized by constant density, high stability and low viscosity. Recent works on the rheology of coal/water slurries revealed that for some particular particle bi-modal distributions the suspension viscosity can be much lower.

A recent survey on sources of magnetite suitable for heavy media, revealed that: there is no experience with the rheology of magnetite heavy media in Canada, there is a worldwide lack of understanding regarding the fundamental aspects of rheology of unstable mineral suspensions.

Thus, in order to study magnetite heavy medium suspension rheology, as related to magnetite particle size distribution, magnetite magnetic properties, and suspension stability, new procedures need to be developed and standardized. Since the resources of Craigmont Mines Ltd., presently major magnetite supplier in Western Canada, are going to be depleted within the next six years at the current production, new magnetite resources must be found. The magnetite could also be reintroduced on international markets of coal producing countries but only if it could meet all new standards which are currently under evaluation in some countries. It is essential that such research be carried out in Canada. A centre able to undertake complete magnetite heavy media testing is proposed.

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Name/Nom: O.P. Malik

Department/Département: Electrical Engineering

University/Université: Calgary

Phone number (optional)/N° de téléphone (facultatif): 403-220-5733

Title of Project/Titre du projet: Microcomputer based adaptive stabilizer for an electric generating unit.

The flexibility and on-board computational capability afforded by a digital device has brought within the realm of feasibility the development of unified approaches and the implementation of more sophisticated control algorithms. A synchronous machine stabilizer using an adaptive self-tuning algorithm has been developed.

The adaptive stabilizer algorithm contains two major parts - a system identifier and a controller. The generating unit is represented by a model of known structure but unknown parameters. The parameters are computed on-line and thus the model tracks the process operating conditions in real-time. To obtain an estimate that is more representative of the current conditions, the identification algorithm uses a variable forgetting factor.

The control strategy is based on a newly developed technique that aims to seek for more closed-loop system stability margin by shifting the system poles radially towards the origin of the unit circle in the z-domain. A variable pole-shifting strategy that shifts poles as close as possible to the origin without violating the practical control constraints is developed.

The controller has been implemented using two microcomputers and a dual-rate control strategy to overcome the contradictory requirements of fast sampling for control and a minimum time required for on-line computations. It has been tested extensively in the laboratory. The objective of the proposed research is to perform field tests with the prototype adaptive stabilizer on an actual power system.

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Ouvert |

Name/Nom: D.F. Measday

Department/Département: Physics

University/Université: University of British Columbia

Phone number (optional)/N° de téléphone (facultatif): (604) 228-5098

Title of Project/Titre du projet: Muon catalyzed fusion.

Muon catalyzed fusion is a potential method of obtaining energy from the fusion of deuterium and tritium, a reaction which is similar to those which are the basis of the energy generation in the sun. Recent research has demonstrated that a single muon can catalyze between 100 and 200 fusions. The atomic and molecular reactions which lead up to this fusion are complex and far from understood. We plan to study pion hydrogen atomic reactions to probe the identical reactions which occur in the muonic system.

The only available pions in Canada are at TRIUMF in Vancouver. In fact the quality of the pions provided by this facility are more appropriate for this research than those provided by any other laboratory in North America. This is thus a unique opportunity for Canada to contribute to the development of a technology which could revolutionize the generation of electricity.

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Name/Nom: A.W. Neumann

Department/Département: Mechanical Engineering and Institute of Biomedical Engineering

University/Université: University of Toronto

Phone number (optional)/N° de téléphone (facultatif): (416) 978-3601

Title of Project/Titre du projet: Bacterial Desulphurization of Coal.

This project is motivated by the need to reduce acid rain arising from the combustion of coal. Canadian coals, particularly those from Eastern Canada contain up to approximately 8% sulphur, partly in the form of organic compounds and partly in the form of an inorganic mineral, pyrite. In the combustion of coal, all these forms of sulphur are oxidized to sulphur dioxide. If emitted into the atmosphere, the sulphur dioxide will react with water to form sulfuric acid, which eventually will be precipitated as acid rain.

The work to be performed is aimed at removal of pyritic sulphur from coal prior to combustion, by bacterial action. There are bacterial species of the genus *Thiobacillus* which "digest" pyritic sulphur in the sense that they catalyze selectively the oxidation of pyritic sulphur, deriving from this reaction the energy necessary for metabolic processes. The end result is sulfuric acid in the reaction vessel, or possibly in a pipeline transporting coal slurries, from which it can be removed without environmental damage. The underlying bacteriological and chemical engineering work is already either in place or being pursued by other laboratories. The present project pursues the optimization of a key event in the process, the adhesion of the bacteria out of their aqueous medium onto the surface of the coal particles. This step is obviously necessary for the catalytic reaction of the pyrite inclusions in the coal. The adhesion process is governed by the surface properties of all three phases, i.e. of the coal, the liquid medium and the bacteria. Therefore we shall establish the surface tension of the bacteria and the coal from wettability studies. From theoretical considerations it will then be possible to adjust the liquid surface tension so as to optimize bacterial adhesion to the particular type of coal considered. The actual extent of bacterial adhesion will then be measured at several liquid surface tensions and compared with the results of actual desulphurization experiments. It is expected that it will become possible to optimize the experimental conditions for the bacterial desulphurization for each type of coal simply by establishing the surface characteristics of that coal. Finally, schemes of removal, collection and recycling of the bacteria from the coal, for economic as well as environmental reasons, will be investigated.

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Name/Nom: Geoffrey A. Ozin

Department/Département: Chemistry

University/Université: Toronto

Phone number (optional)/N° de téléphone (facultatif): 416-978-2082

Title of Project/Titre du projet: ALKANE ACTIVATION BY INTRAZEOLITE ORGANOMETALLICS

ABSTRACT

The specific objective of this proposal is the encapsulation of precursors to alkane-activating organometallics in the accessible supercages of various faujasites. These new materials will then be converted into highly reactive systems capable of activating and functionalizing alkanes. The zeolite will serve to stabilize coordinatively unsaturated organometallics and impose size and shape selectivity on the products. The ultimate goal is to establish new routes for tapping the chemical potential of the methane molecule. With prospects in Canada reasonably good for maintaining secure, reliable and adequate supplies of natural gas into the future, it is appropriate that research be intensified on alkane and methane reaction science in Canada.

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Name/Nom: H.O. Pritchard

Department/Département: Chemistry

University/Université: York

Phone number (optional)/N° de téléphone (facultatif): 416-667-3847

Title of Project/Titre du projet: Improving the detonability of diesel fuels

In recent years, there has been a change in the pattern of hydrocarbon fuel consumption in this country - there has been a decrease in the demand for gasoline and heating oil relative to that for diesel and aviation fuel. The position now is that virgin crude, subjected to conventional refinery distillation, can no longer be made to produce an acceptable balance of products, and there is a shortage of diesel and jet fuels relative to gasoline and heating oil.

In order to maintain this country's self-sufficiency in oil, it is attractive to try to augment the diesel and jet fuel supply by blending in material derived either from catalytic or coker processing of the heavier distillation fractions, or else from tar sands. However, these alternative materials are high in polyaromatic hydrocarbons containing three or more fused aromatic rings. This high PAH content confers unsatisfactory burning properties on diesel and jet-aircraft fuels derived from these blends: their cetane values are low, which means that in a diesel engine, the fuel does not ignite sufficiently quickly; in jet engines, they make smoke, which is unacceptable.

In the past, the diesel engine problem has been mitigated by adding "promoters" to the fuel - typically alkyl nitrates or alkyl peroxides - but if we allow the PAH content to rise any higher, we will reach the point where these promoters will become ineffective.

The work outlined in this proposal is intended to solve the diesel engine ignition problem, and at the same time, it is hoped that it may provide some pointers to a solution of the jet engine problem.

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Name/Nom: Silveston, P.L.

Department/Département: Department of Chemical Engineering

University/Université: University of Waterloo

Phone number (optional)/N° de téléphone (facultatif): (519) 885-1211 Ext. 2541

Title of Project/Titre du projet: Synthetic Coke and Metallurgical Carbon from Coal Char

Can we make better use of our coal resources? One possibility for making better use is to maximize the recovery of the potentially valuable coal liquids and tar from coal before coal is used for iron making or for generating power. After all, prior to World War II, coal liquids and tar were the basis of the organic chemical industry. This possibility can only be successful if the char that is left over can be burnt in a power plant or made into a coke economically. The research to be undertaken is aimed at learning if the chars produced when trying to recover liquids and tar can be used to make synthetic coke or if the chars can be used directly in making iron. Just under a 3 year effort will be needed and will cost about \$75,000. Top notch facilities in the Coal Research Laboratory at the University of Waterloo will be used.

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Name/Nom: J. P. Sislian

Department/Département: Institute for Aerospace Studies

University/Université: University of Toronto

Phone number (optional)/N° de téléphone (facultatif):

Title of Project/Titre du projet: Experimental and Theoretical Investigation of Practical Gas Turbine Combustor Flows.

The objectives of the present research programme are: (1) to map the velocity field (mean flow and turbulence intensities) in a one-to-one scale model of practical chamber in isothermal and combustng situations (Pratt & Whitney small helicopter engine annular combustor); (2) to identify the deficiencies and/or limitations in current aerothermal models for turbulent combustng flows by testing model prediction results against obtained data base, and (3) to assess the potential of various models for predicting combustor flowfields by comparing numerical results of mathematical models to experimental data obtained in the Pratt & Whitney combustor. The long term objective is to develop computational fluid dynamic prediction models for improved combustor design and analysis, and to minimize combustor development time and cost requirements. In the experimental part of the research project the main tool to be used is a two-dimensional 3W Argon ion laser Doppler velocimeter with a Bragg cell, operating in differential Doppler forward or backscatter, mode. The system represents a most sophisticated instrument for the simultaneous measurement of two-components of the instantaneous velocity in complex turbulent flowfields which may contain reverse flow regions. The data acquisition and reduction will be performed by a Motorola 32-bit VME-20 minicomputer. In the numerical prediction part of the research project, the approach consists of a finite-difference solution of the time-averaged, steady state elliptic form of the Reynolds equations in primitive variables. Turbulence is modelled by a variety of models of increasing complexity, from the basic $k-\epsilon$ to algebraic Reynolds stress equations, including modified forms of these models. Combustion will be by: (1) a simple, irreversible, one-stop chemical reaction, with eddy break-up model; (2) equilibrium chemistry, and (3) finite rate chemistry of methane/air combustion.

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Name/Nom: W. W. Smeltzer

Department/Département: Materials Science & Engineering

University/Université: McMaster

Phone number (optional)/N° de téléphone (facultatif): 416-525-9140

Title of Project/Titre du projet: Tritium Diffusion and Permeation Barrier Technology

This project emphasizes a research and development program at both the fundamental and technological levels on tritium - materials surface interactions as they relate to fusion power reactors, isotope separation and tritium immobilization reactors, and tritium storage vessels. Structural alloys for the outer exchange walls of fusion reactors require barriers able to reduce tritium permeation by at least two and preferably four orders of magnitude in order to keep tritium release within environmental safety limits. Metal-ceramic laminate coatings provide the best potential for this purpose; consequently, this research is concerned with the preparation, characterization and tritium permeation properties of Al_2O_3 barriers under normal isothermal conditions and under conditions of irradiation damage and impressed temperature gradients. Tritium permeation properties will be investigated of Al_2O_3 barriers prepared by four methods: controlled atmospheric oxidation of Ni-Al alloys, electrolytic anodic oxidation of evaporated Al films on Ni, chemical vapor deposition and sintering of Al_2O_3 layers of Ni-Al alloys by ion beam implantation and mixing techniques. The effects of irradiation damage and temperature gradients on these metal- Al_2O_3 laminate coatings are to be determined using ion accelerator and nuclear analytical techniques.

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Name/Nom: SMY, P.R.

Department/Département: ELECTRICAL ENGINEERING

University/Université: ALBERTA

Phone number (optional)/N° de téléphone (facultatif):

Title of Project/Titre du projet: THE USE OF ELECTRICALLY INDUCED TURBULENCE IN COMBUSTION

With suitable electrical and mechanical design it is possible to produce a modified type of spark plug that generates a cloud of turbulence following the spark. As is well known turbulence can increase combustion rate and as a result such spark plugs can provide better mileage in automobile use. In addition to creating turbulence these plugs can also impart momentum to the turbulent cloud so that the centre of combustion moves to a more desirable location e.g. away from a wall. This latter property may well be useful in 'difficult to ignite' situations such as jet engines and flare stacks. The major focus of this particular investigation is upon the possibility of using two sparks -one to ignite and one to create turbulence, and the ability to move the centre of combustion.

SUMMARY FOR PUBLICATION/RÉSUMÉ À PUBLIER

FIELD OF RESEARCH / DOMAINE DE RECHERCHE

(Check one/cocher la case appropriée)

☐ Biotechnology /
Biotechnologie

☐ Communications and Computers /
Télécommunications et informatique

☒ Energy /
Énergie

☐ Environmental Toxicology /
Toxicologie de l'environnement

☐ Food-Agriculture /
Alimentation-Agriculture

☐ Industrial Materials and Processes /
Matériaux et procédés industriels

☐ Oceans /
Océans

☐ Open /
Ouvert

Name/Nom: F. R. Steward and D. Karman

Department/Département: Chemical Engineering

University/Université: University of New Brunswick

Phone number (optional)/N° de téléphone (facultatif): 453-4517

Title of Project/Titre du projet: Combustion and Retorting Properties of Oil Shale

New Brunswick has reserves of both high sulfur and low grade oil shale. The coal gives rise to SO_2 pollution when it is burned in conventional boilers and the oil content of the shale is too low to make it attractive as a fuel source at the present. The possibility of using these two sources together has been investigated in recent years. If coal is burned with oil shale, the SO_2 generated by the combustion can be partly absorbed by the calcium in the shale. The oil content of the shale contributes to the energy generation. Alternately, a retort-combustor combination can be used where part of the energy from the combustor can be used to drive off the oil in the shale retort for later recovery. The spent shale from the retort can in turn be used for sulfur capture in the combustor.

This project is designed to obtain information on the rates of thermal decomposition and sulfation reactions that take place when oil shale is introduced into a combustor or retort. In a thermogravimetric apparatus, the weight loss/gain of samples is measured as a function of time at different temperatures, gas environments, oil shale composition and particle size. The behaviour of shale samples in a fluidized bed will also be investigated as this is the type of reactor suitable for both combustors and retorts. The shale samples used in the reactor can be examined for their sulfur content and surface area to monitor the progress of reactions taking place. The modelling of the observed behaviour can enable the design and optimization of large scale applications.

SUMMARY FOR PUBLICATION/RÉSUMÉ À PUBLIER

FIELD OF RESEARCH / DOMAINE DE RECHERCHE

(Check one/cocher la case appropriée)

- | | | | |
|---|--|---|---|
| ☐ Biotechnology /
Biotechnologie | ☐ Communications and Computers /
Télécommunications et informatique | ☒ Energy /
Énergie | ☐ Environmental Toxicology /
Toxicologie de l'environnement |
| ☐ Food-Agriculture /
Alimentation-Agriculture | ☐ Industrial Materials and Processes /
Matériaux et procédés industriels | ☐ Oceans /
Océans | ☐ Open /
Ouvert |

Name/Nom: B. Y. Tong

Department/Département: Physics

University/Université: The University of Western Ontario

Phone number (optional)/N° de téléphone (facultatif): (519) 679-2285

Title of Project/Titre du projet: Amorphous Silicon Thin Film Tandem Solar Cells

It has been known for some time that electric power can be generated directly from sunlight by means of solar cells made on silicon wafers. Silicon wafers cut from crystals are expensive, but silicon amorphous in the form of thin films is cheaper to produce and it absorbs sunlight much more efficiently.

Already amorphous silicon solar cells are produced in Japan to operate pocket calculators. However, amorphous silicon material produced in the conventional way is unstable, especially under strong illumination or when it is heated above 300°C. In 1983, we received a U.S. patent on making a stable form of amorphous silicon thin film. Recently, we further developed a method of making high quality doped amorphous silicon thin films. In the present project we shall fabricate solar cells out of the doped and undoped materials produced in our laboratories.

J.E.S. Venart

Name/Nom:

Department/Département: **Mechanical Eng.**

University/Université: **New Brunswick**

Phone number (optional)/N° de téléphone (facultatif):

Title of Project/Titre du projet: **Pressure liquefied fuel tank thermal response**

NO SUMMARY AVAILABLE

SUMMARY FOR PUBLICATION/RÉSUMÉ À PUBLIER

FIELD OF RESEARCH / DOMAINE DE RECHERCHE (Check one/cocher la case appropriée)

- | | | | |
|---|--|---|---|
| ☐ Biotechnology /
Biotechnologie | ☐ Communications and Computers /
Télécommunications et informatique | ☒ Energy /
Énergie | ☐ Environmental Toxicology
Toxicologie de l'environnement |
| ☐ Food-Agriculture /
Alimentation-Agriculture | ☐ Industrial Materials and Processes /
Matériaux et procédés industriels | ☐ Oceans /
Océans | ☐ Open /
Ouvert |

Name/Nom: Roger G. Walker
 Department/Département: Geology
 University/Université: McMaster Univ.
 Phone number (optional)/N° de téléphone (facultatif): (416) 525-9140, ext. 4189
 Title of Project/Titre du projet: Origin of reservoir sandstones and conglomerates, Alberta.

Oil and gas generated within the sedimentary layers of the Earth's crust must be trapped in reservoirs, which are normally also sedimentary rocks. The shape, size, thickness, orientation and location of the reservoirs depends largely upon how the reservoir rocks originally formed. The thrust of this research is to study reservoir formation in Cretaceous rocks (some 130 to 65 million years old) that were deposited in an extensive Seaway that covered the western Plains of Canada and the US. Many of the reservoirs consist of long, narrow "ridges" of sand and gravel, which are now encased in marine shales. It has been assumed that the ridges were deposited a long way seaward from the Cretaceous shoreline, by shallow marine tidal and/or storm currents that somehow "focussed" the shifting sediment into the ridges. However, there has been no understanding of how the currents made the ridges, nor of where the ridges might form. In this ignorance, prediction of new reservoirs is almost impossible, and extension of existing reservoirs is difficult.

My research has shown that many of the "ridges" are underlain by extensive erosion surfaces that were scoured by waves during times of lowered sea level. In the Cardium Formation, one of Canada's largest oil reservoirs, seven erosion surfaces were cut within a period of about 1 million years. During low stands of sea level, the shoreline moves toward the centre of the Seaway, and a new shoreface is scoured by the waves, making a "step" in the erosion surface. Sand and gravel is transported to the shoreline by rivers, and is redistributed along the shoreface by waves. When sea level rises again, the shoreface sands and gravels are buried by marine shales, forming a potential reservoir with a shaly trapping layer above. Thus, rather than forming way offshore by marine currents focussing sediment into "ridges", many of the reservoirs are localized by the various positions of the shoreline during the sea level fluctuations. Reservoir thickness depends on the depth of wave scour, and orientation depends on the trend of the shoreline. My research will be to document the history of sea level change, and relate it to a pattern of shifting shorelines, and hence reservoir localization. The work is well advanced for one of the seven Cardium erosion surfaces, but must be extended to the other six before general principles can be established. Erosion surfaces are known locally in the Viking Formation, and research will concentrate on their extent, and whether they appear to control the location of reservoir sediments to the same extent as in the Cardium. The general principles established from these two formations should be applicable to exploration and reservoir development in all areas of Canada, onshore and offshore.

LIST OF ONGOING RESEARCH PROJECTS / LISTE DES PROJETS DE RECHERCHE EN COURS

Energy / Énergie

Name/Nom	Department/Département	University/Université	Title/Titre	\$*	Page
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1. Energy Conservation/ Conservation de l'énergie

Eastham, A.R. Electrical Eng. Queen's	Development and application of the finite element technique as a design and diagnostic tool for energy efficient machines and electromagnetic devices * with J.C. Beal, G.E. Dawson (Queen's)	191,100
Hill, P.G. Mechanical Eng. British Columbia	Flame speed enhancement for alternative fuels in I.C. engines * with R.L. Evans (UBC)	210,880
Rajagopalan, V. Ingénierie Qué.-Trois-Riv.	Recherche et développement de nouvelles stratégies de commande des défibreurs pour réduire la consommation d'énergie * avec J.J. Garceau (UQTR)	125,000
Rhodes, E. Chemical Eng. Waterloo	Research into a new boiler control system utilizing new fouling monitoring technology * with J.R. Wynnkyj (Waterloo)	201,000
Saravanamuttoo, H.I.H. Mech. & Aeronaut. Carleton	Fouling of gas turbine compressors	76,500

2. Energy Conversion and Storage/ Conversion et stockage de l'énergie

Aubke, F. Chemistry British Columbia	Synthesis of lithium salts used as electrolytes in secondary lithium batteries	105,120
Galibois, F. Mines & métallurgie Laval	Comportement électrochimique et mécanique des matériaux (acier et aluminium) utilisés pour la fabrication des cylindres servant à l'emmagasinement et au transport du gaz naturel comprimé * avec E.Ghali, M.Fiset (Laval)	258,000

* Total funds committed/Montant total accordé

Energy/Énergie

Name/Nom	Department/Département	University/Université	Title/Titre	\$*	Page
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2. Energy Conversion and Storage/ Conversion et stockage de l'énergie

Jacobs, P.W.M.	Chemistry	Western Ontario	Solid state polymer-based secondary batteries * with J.W. Lorimer (UWO)	185,016	
Strom-Olsen, J.O.	Physics	McGill	Hydrogen storage in metallic glasses * with Z. Altounian, R. Harris, W.B. Muir (McGill)	200,500	

3. Energy Transportation and Distribution/ Transport et distribution de l'énergie

Atherton, D.L.	Physics	Queen's	Magnetic inspection tools for pipelines	228,650	
Semlyen, A.	Electrical Eng.	Toronto	Optimal load flow using network flow programming	147,000	

4. Fossil Fuels/ Combustibles fossiles

Al Taweel, A.M.	Chemical Eng.	Tech. Univ. N.S.	Intensive coal cleaning for the production of coal/liquid fuel mixtures * with G.D.M. MacKay, B.H. Chen (TUNS)	205,500	
Basu, P.	CREN	Tech. Univ. N.S.	Heat transfer in high temperature circulating fluidized bed combustors * with B.H. Chen (TUNS)	144,100	
Becker, H.A.	Chemical Eng.	Queen's	Basic studies relating to fluidized bed combustion	168,600	
Charles, M.E.	Chemical Eng.	Toronto	Rheological characteristics of gelled Canadian Arctic crude oils and modelling of heat loss from storage tanks and pipeline	103,240	
Costerton, J.W.	Biology	Calgary	Enhanced oil recovery by mobility control using bacterial nutrients	302,700	

* Total funds committed/Montant total accordé

Energy/Énergie

Name/Nom Department/Département University/Université	Title/Titre	\$*	Page
4. <u>Fossil Fuels/</u> <u>Combustibles fossiles</u>			
Kaiser, P.K. Civil Engineering Alberta	Deep borehole rupture mechanics * with J.D. Scott (Alberta)	215,000	
Pintar, M.M. Physics Waterloo	Investigations of phases and structures of oil sands and oil-water mixtures at the molecular level	45,900	
Scott, J.D. Civil Engineering Alberta	Core sampler for oil sands and heavy oil formations	214,820	
Toth, J. Geology Alberta	Development of a hydro- geological approach to petroleum exploration	285,240	
5. <u>Nuclear Energy/</u> <u>Energie nucléaire</u>			
Graham, J. Civil Engineering Manitoba	Sand-clay buffers for nuclear waste disposal at elevated temperatures	155,660	
Haasz, A.A. Aerospace Studies Toronto	Fusion materials research using tritium * with P.C. Stangeby (Toronto)	315,000	
Hirose, A. Physics Saskatchewan	Fusion research with STOR-1M and STOR-M tokamaks * with H.M. Skarsgard (Sask.)	521,600	
Manchester, F.D. Metall./Mat. Science Toronto	Hydrogen - metal surface interactions * with G.C. Weatherly, C.A. Ward, J.S. Hewitt (Toronto)	150,000	
Meyer, J. Physics British Columbia	Plasma physics of the laser fusion target * with A.J. Barnard, A. Ng (UBC)	300,000	
Munz, R.J. Chemical Eng. McGill	Vitrification of nuclear waste in a transferred arc plasma	88,880	

* Total funds committed/Montant total accordé

Energy/Énergie

Name/Nom Department/Département University/Université		\$*	Page
5. <u>Nuclear Energy/</u> <u>Énergie nucléaire</u>			
Nirdosh, I. Québec Engineering Lakehead	Processes for obtaining environmentally safe uranium mill tailings	165,240	
Offenberger, A.A. Electrical Eng. Alberta	Laser fusion related research * with R. Fedosejevs, W. Rozmus (Alberta)	420,000	
Pépin, H. INRS-Énergie Univ. du Québec	Études d'interaction laser- matière reliées à la fusion et applications * avec P. Lavigne, P. Martin, T.W. Johnston, R. Décoste (INRS)	300,000	
Saint-Jacques, R.G. INRS - Énergie Univ. du Québec	Revêtements réfractaires - refractory coatings * avec C. Boucher, B. Terreault (INRS), S. Dallaire (IMRI)	143,500	
6. <u>Renewable Resources/</u> <u>Ressources renouvelables</u>			
Brodie, D.E. Physics Waterloo	Polycrystalline photovoltaic cells * with A.E. Dixon, J.D. Leslie, C.J.L. Moore (Waterloo)	159,000	
Leblanc, R.M. Photobiophysique Qué.-Trois-Riv.	Cellules photovoltaïques à base de pigments biologiques	186,580	
Shih, I. Electrical Eng. McGill	Electrodeposition of CuInSe ₂ thin films for photovoltaic application	173,000	

* Total funds committed/Montant total accordé

LIST OF SUMMARIES OF COMPLETED PROJECTS /
LISTE DES RÉSUMÉS DES TRAVAUX DE RECHERCHE TERMINÉS

Energy / Énergie

Name/Nom Department/Département University/Université	Title/Titre	\$*	Page
1. <u>Energy Conservation/</u> <u>Conservation de l'énergie</u>			
Besant, R.W. Mechanical Eng. Saskatchewan	Low energy building monitoring, analysis and simulation * with G.J. Schoenau (Saskatchewan)	236,880	58
Karim, G.A. Mechanical Eng. Calgary	The combustion of gaseous fuels containing significant amounts of dilutents	80,500	70
Kind, R.J. Mech. & Aeronaut. Carleton	Flow in small centrifugal fans	36,450	71
Smy, P.R. Electrical Eng. Alberta	Enhancement of flame and transport processes in pulsed plasma plugs	144,510	79
Tanaka, H. Civil Engineering Ottawa	Air infiltration of high-rise buildings for energy calculation * with Y. Lee (Ottawa)	84,580	81
2. <u>Energy Conversion and Storage /</u> <u>Conversion et stockage de l'énergie</u>			
Barradas, R.G. Chemistry Carleton	Low temperature investigations of electrode processes in the lead acid battery system	116,665	55
Conway, B.E. Chemistry Ottawa	Evaluation et electrocatalysts for water electrolysis and H2/O2 fuel cells	213,000	62
3. <u>Energy Transportation and Distribution /</u> <u>Transport et distribution de l'énergie</u>			
Robillard, L. Génie civil École Polytechnique	Effet des basses températures sur les systèmes de refroidissement utilisés dans les réseaux électriques * avec P. Vasseur (École Polytechnique)	118,500	75

* Total funds awarded/Montant total accordé

Energy / Énergie

Name/Nom Department/Département University/Université	Title/Titre	\$*	Page
4. <u>Fossil Fuels /</u> <u>Combustibles fossiles</u>			
Barbery, G.A. Mines & métallurgie Laval	Flocculation sélective des fines de charbon	91,400	56
Buckmaster, H.A. Physics Calgary	Clay treatment and stabilization studies for enhanced oil recovery	144,000	60
Cormack, D.E. Chemical Eng. Toronto	Numerical simulation of hydraulic fractures for hydrocarbon recovery	133,420	63
Dullien, F. Chemical Eng. Waterloo	Development of new core analysis * with I. Chatzis, I.F. Macdonald (Waterloo)	208,222	66
Hornof, V. Chemical Eng. Ottawa	Enhanced oil recovery using lignin waste products * with G.H. Neale (Ottawa)	108,000	67
Hron, F. Physics Alberta	Computer inversion of geophysical data using inverse methods and direct numerical modeling * with M. Razavy (Alberta)	243,360	68
Jervis, R.E. Chemical Eng. Toronto	Compositional characterization of combustion condensate particulates from energy sources	89,135	69
Masliyah, J.H. Chemical Eng. Alberta	Application of inclined plate settles to separation of bitumen-sand slurry * with K. Nandakumar (Alberta)	91,700	73
Sorensen, T.S. Chemistry Calgary	A study of the chemical reactions occurring in the liquid products during thermal coking of bitumen	38,730	80
Walker, R.G. Geology McMaster	Reservoir geometry and prediction of shallow marine sandstones, Alberta	173,140	82

* Total funds awarded/Montant total accordé

Energy / Énergie

Name/Nom Department/Département University/Université	Title/Titre	\$*	Page
5. <u>Nuclear energy /</u> <u>Énergie nucléaire</u>			
Chatt, A. Chemistry Dalhousie	Studies on physico-chemical forms of neptunium in groundwater	152,940	61
Selvadurai, A.P.S. Civil Engineering Carleton	Thermo-mechanical interactions in a container-buffer-rockmass system in a nuclear waste disposal vault during water uptake	195,000	77
6. <u>Renewable Resources /</u> <u>Ressources renouvelables</u>			
Beeckmans, J.M. Chem./Biochem. Eng. Western Ontario	Development of a simple dual-bed fluidized gasifier for biomass and other pyrolyzable wastes	65,728	57
Bolton, J.R. Chemistry Western Ontario	Photochemical solar energy conversion in linked donor-acceptor molecules * with A.C. Weedon, M.J. Stillman (Western Ontario)	336,000	59
Dao, L.H. INRS - Énergie Univ. du Québec	Cellules photovoltaïques et photoélectrochimiques à base de semiconducteurs organiques électropolymérisés * avec J.P. Dodelet (INRS), D. Gravel (Montreal)	124,995	64
Parsons, R.R. Physics British Columbia	The utilization of planar magnetron sputtering: Thin films for solar energy applications	181,040	74
Scott, D.S. Chemical Eng. Waterloo	Development of an atmospheric pressure flash pyrolysis project	135,000	76

* Total funds awarded/Montant total accordé

Energy / Énergie

Name/Nom Department/Département University/Université	Title/Titre	\$*	Page
7. Other / Autres			
Dhillon, B.S. Mechanical Eng. Ottawa	Nuclear and conventional energy production and transmission systems reliability and safety assurance methods	77,950	65
Lavers, J.D. Electrical Eng. Toronto	Portable data acquisition and diagnostic facility for electric arc furnace disturbances	99,001	72
Sheasby, J. Eng. Materials Western Ontario	The direct observation of lubricated wear	101,000	78
West, G.F. Physics Toronto	Seismic tomography	187,200	83

* Total funds awarded/Montant total accordé

SUMMARIES OF COMPLETED RESEARCH PROJECTS /

TRAVAUX DE RECHERCHE TERMINÉS

FIELD Or RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology /
technologie
☐ Agriculture /
Agriculture

☐ Communications and Computers /
Télécommunications et informatique
☐ Industrial Materials and Processes /
Matériaux et procédés industriels

☒ Energy /
Énergie
☐ Oceans /
Océans

☐ Environmental Toxicology /
Toxicologie de l'environnement
☐ Open /
Ouvert

Name/Nom: R.G. Barradas

Department/Département: Chemistry, Carleton University, Ottawa, Ontario K1S 5B6

University/Université:

Phone number (optional)/N° de téléphone (facultatif): 613-564-2744

Title of Project/Titre du projet: "Low Temperature Investigations of Electrode Processes in the Lead Acid Battery System"

Photochemical and Electrochemical Techniques were used to investigate the kinetic barriers to the preferred reactions occurring at ambient temperatures. The investigations centred on comparison of electrode active materials and their properties at room temperature and at sub zero temperatures down to -37°C . At -37°C the photoelectrochemical results are dramatically different from those obtained at room temperature. A new region of photo-activity was observed. The reduction of $\beta\text{-PbO}_2$ to PbSO_4 proceeds via the formation of an intermediate stage of lead monoxide. Various inorganic additives such as salts of Tl(I) , Bi(III) and Te(VI) were investigated. No significant charge-discharge behaviour was observed for Bismuth and Tellurium. However the addition of Thallium results in about 10 to 20% increase in the anodic current at the end of the charge region i.e. at 1.6 volt (vs. $\text{Hg/Hg}_2\text{SO}_4$ reference electrode). Thallium decreases significantly the value of the peak current for the reduction of PbO_2 to PbSO_4 . However the total reduction charge in the presence or absence of the Tl remained constant despite the change in the shape of the discharge voltammograms. The addition of Tl also affects the negative plate. Our results indicate that the presence of Tl interferes with the PbSO_4 electrocrystallisation process, possibly by producing some diffusion limitations. At ambient temperatures there is no evidence of hydrogen peroxide formation but at sub-zero temperatures the reduction of O_2 on Pb seems to lead to H_2O_2 formation which is supposed to have a detrimental effect on the performance of the positive plate. Ammonium lignosulphonate was examined extensively as an expander additive in the course of 3-Dimensional Nucleation and Growth of PbSO_4 . The expander adsorbs strongly on the electrode and scanning electron micrographs show that a more porous film is obtained. Increasing concentrations of expander increased the amount of charge required for passivation. The effect of the expander did not alter the value of the activation energy of PbSO_4 formation. At subzero temperatures the onset of passivation was delayed.

Publications arising from this work:

- 1) R.G. Barradas, D.S. Nadezhdin and N. Shah, J. Electroanal. Interfacial Electrochem. 147, 193 (1983).
- 2) R.G. Barradas and D.S. Nadezhdin, J. Electroanal. Interfacial Electrochem. 158, 165, (1983).
- 3) R.G. Barradas and D.S. Nadezhdin in "Advances in Lead Acid Batteries", E.C.S. Monograph, Eds. D. Pavlov and K. Bullock, pp. 126-141 (1984).
- 4) R.G. Barradas, D.A. Rennie and T.J. VanderNoot, Can. J. Chem., 63, 2437, (1985).
- 5) R.G. Barradas and D.S. Nadezhdin, J. Electroanal. Interfacial Electrochem. (in press 1986).
- 6) N. Shah, Honours B.Sc. Dissertation, Carleton University (1983).
- 7) K. Briere, Honours B.Sc. Dissertation, Carleton University (1984).
- 8) D.A. Rennie, M.Sc. Thesis (Summer 1986).

Name/Nom: Gilles Barbery
Department/Département: Mines et Métallurgie
University/Université: Laval
Phone number(Optional)/N° de téléphone (facultatif): 418-656-2555
Title of Project/Titre du projet: Flocculation sélective du charbon

La flocculation sélective est un procédé de séparation des phases solides dans lequel on sépare les phases présentes sous forme de très petites particules (inférieures à 50 micromètres), en se servant de l'adsorption différentielle d'une macromolécule soluble dans l'eau dont la fonction est de former des agglomérats (flocs) constitués d'une seule phase. Il est alors possible de séparer les flocs par des techniques simples comme la sédimentation. L'application au traitement des minerais de charbon pourrait trouver deux applications, l'une pour la production de superconcentrés à utiliser sous forme de mélanges avec l'eau ou avec l'huile, afin de remplacer les hydrocarbures dans les centrales de production de vapeur, et l'autre pour récupérer la fraction fine des minerais de charbon qui est actuellement perdue dans les procédés utilisés industriellement. La recherche qui a été réalisée avait pour principaux objectifs de définir les principales contraintes qui peuvent s'appliquer à un tel procédé. On a travaillé sur des mélanges de charbon de Nouvelle-Ecosse et de kaolin (1/1), et on a réussi, au laboratoire, en une seule étape de séparation, à produire des concentrés de charbon dans lesquels le rendement en charbon était supérieur à 90% avec un taux d'élimination des cendres supérieur à 50%. La phase initiale de dispersion globale des phases est indispensable et peut être réalisée dans l'eau de ville, à pH 7 et en présence de métaphosphate de sodium utilisé comme dispersant (100g/t). On peut se servir, comme macromolécule pour la flocculation sélective, de polyacrylamide anionique ou d'oxyde de polyéthylène, de poids moléculaires supérieur à 1 million. On a démontré l'influence très néfaste d'une intensité d'agitation élevée au cours du mélange de la pulpe dispersée avec le flocculant, d'une trop forte concentration en solides (supérieure à 2%), et de la dureté de l'eau. Les résultats ont été vérifiés à l'échelle pilote dans un montage continu d'une capacité de 1 l/min. Des essais de flocculation globale sur le rejet de la séparation primaire ont montré qu'il est possible d'effectuer une séparation solide/liquide efficace sans changer la chimie globale de l'eau de procédé. Un ajout de 150g de polyacrylamide neutre de poids moléculaire élevé, par tonne de solide à éliminer est suffisant pour donner une eau clarifiée. Des essais de compatibilité de cette eau avec les conditions initiales du procédé, permettant d'en évaluer le recyclage, a montré que l'on dégradait progressivement les performances, même lorsque la quantité de dispersant était maintenue à un niveau constant en solution, en raison probablement de la présence de flocculant résiduel dans l'eau recyclée. Un essai continu intégré a montré, cependant, qu'une simulation de lagunage de quatre jours permettait de retrouver la sélectivité initiale. Il n'en reste pas moins que dans le développement de tout procédé de flocculation sélective, une attention très particulière, tant au point de vue technique qu'au point de vue économique, doit être portée aux caractéristiques du réactif le plus important utilisé, qui est l'eau, dont le recyclage, pour des raisons environnementales ou économiques, doit être réalisé.

(CHECK ONE COLUMN as most appropriate)

- ☐ Biotechnology
☐ Food Agriculture /
Alimentation Agricoltura

- ☐ Communications and Computers
Télécommunications et informatique
☐ Industrial Materials and Processes
Matériaux et procédés industriels

- ☒ Energy
Océans
☐ Océans

- ☐ Environmental Technology /
Technologie de l'environnement
☐ Open /
Ouvert

Name/Nom: John M. Beeckmans

Department/Département: Chemical and Biochemical Engineering

University/Université: The University of Western Ontario

Phone number (optional)/N° de téléphone (facultatif): (519) 661-2131

Title of Project/Titre du projet: Development of a Simple Dual-Bed Fluidized Gasifier for Biomass and Other Pyrolyzable Wastes

Biomass and other carbonaceous waste materials can be converted into a useful gas by the application of intense heat in the absence of oxygen. In one type of gasifier the heat is provided by burning part of the material in air, and using the combustion products plus added steam to heat up and gasify the rest. This type of process produces a gas of low calorific value which contains a large proportion of nitrogen and carbon dioxide. Alternatively pure oxygen may be used in lieu of air, but this is clearly an expensive route. In another type of gasifier two sand-filled interconnected vessels are used. One vessel to which biomass is fed, is fluidized with steam, and gasification occurs here. The second vessel is fluidized with air, and its purpose is to burn residual, ungasified material (mainly char), coming from the first vessel. The sand circulates between the two vessels and serves two purposes: to carry heat from the combustor vessel to the gasifier, and to carry char from the gasifier to the combustor. This type of gasifier has been operated successfully on a commercial scale in Japan to gasify municipal wastes, and it produces a gas of medium quality which is essentially uncontaminated with nitrogen.

The objective of the present project was to develop a simple, small-scale gasifier along these lines. In the event, largely because such a gasifier was developed in Japan after the application was submitted, a somewhat different approach was used. In this approach a single-vessel gasifier is operated on a cyclic basis. At the start of the cycle the biomass is added to a bed of coarse sand at 900°C and is immediately mixed by spouting with steam. Gasification then occurs, and is permitted to proceed until no more gas is produced. The residual char is subsequently burnt using air to bring the temperature of the sand back to its original value. The exhaust gases for the two stages of the cycle leave by different exits and do not mix, so that the pyrolysis gas is uncontaminated by nitrogen. The gasifier thus produces gas of a similar quality to that found using two-vessel gasifiers.

A pilot plant operating on this basis was designed on the basis of 10 kg/hr of biomass pellets, and was successfully operated. Gas with a calorific value in the range 10 - 15 MJ/SCM was produced. Calculated carbon conversion efficiencies in the range 24-75% were found, but these figures are subject to a significant degree of uncertainty because of the difficulty in doing a mass balance in a cyclic process in which flowrate and gas composition change continuously over time. The potential advantages of the process are simplicity of equipment and operation, low capital cost, lower steam consumption and greater thermal efficiency relative to two-vessel gasifiers. The single-chamber cyclic gasifier was subsequently converted to automatic operation under control of a microprocessor.

Further development is needed before the process can be commercialized. Improvements needed include heat exchangers to heat incoming air and steam, a means of collecting and recycling tars, cyclones to prevent carry-over of char, and a provision of a gasometer to collect an integrated product sample.

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Title of Project/Titre du projet: NSERC Strategic Grant G1000

Low Energy Building Monitoring, Analysis and Simulation

OBJECTIVES

The general objective was to measure auxiliary energy consumption in low energy passive solar buildings. More specifically, the purpose was to measure the dynamic performance of low energy passive solar houses and buildings and to test energy transfer components, such as insulation, air to air heat exchangers, windows, basement floors, etc., in situ and in the laboratory. Dynamic computer simulations were to be validated against these measured data. Finally, systems and components were to be evaluated in terms of their cost effectiveness.

ACHIEVEMENTS

The researchers investigated a large number of questions about cost effective energy conservation features in buildings, especially houses. A few conclusions from these studies on houses are:

1. The optimum energy conservation and passive solar features are highly dependent on climatic conditions in North America. This makes universal design and construction standards even across Canada inappropriate. Much higher levels of energy conservation appear to be economically justified than is the current building practice.
2. With present technology and economic conditions, extra passive solar investments in houses are not economically competitive with better energy conservation measures in cold climates or for houses dominated by internal gains. Nonetheless, as windows are required for other reasons, such as, natural daylighting, external view, internal and external appearance, natural ventilation and fire safety, it is more economical to place the majority of them facing south where winter solar gains reduce the heat load and eave overhangs reduce the summer direct solar gains.
3. Window thermal resistance is very important for most regions of North America. Triple but not quad-glazing appears to be justified in most regions. Super windows or window shutters (RSI 1.76) with high solar transmissivity might be worth an extra 200 dollars per square metre on the northern prairies and other cold winter climates.
4. Large uncertainties are present in the existing published data on heat loss from basements especially uninsulated ones. Basement heat flux takes place through a basement envelope of high thermal conductivity surrounded by a non-homogeneous soil of undetermined time varying thermal properties such as temperature, thermal conductivity, and thermal diffusivity with time varying boundary conditions at each surface. Radiation, not heat convection, is the prime mode of heat exchange among internal basement surfaces and especially to the basement floor.
5. Continuous basement floor insulation without thermal bridges may reduce basement floor heat losses by 50% or more as well as improve the thermal comfort level.
6. Heat recovery ventilators may be justified for housing for a number of reasons in addition to energy savings, but their high installed cost and occasional lack of reliability have limited their application.
7. The researchers have concluded, through experimental and theoretical studies, that the performance and reliability of heat recovery ventilators can be improved by increased air flow capacity, better defrost schemes and improved installation and maintenance.

The researchers have investigated a number of questions with respect to larger buildings. Some conclusions which have resulted from this research work are:

8. Heat recovery design may be made more cost effective using the new design methods developed for run-around liquid coupled heat exchangers.
9. Active thermal storage may be justified in some large buildings under certain utility rate structures but it is not justified for most buildings.
10. Thermal insulation in walls and roofs, window size, HVAC system components may be optimized in the design of large buildings using methods developed by the researchers. Although a large number of building features may be optimized, window surface area should be minimized for most buildings in most climates.

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 Title of Project/Titre du projet: Photochemical Solar Energy Conversion
 in Linked Donor-Acceptor Molecules

The primary photochemical energy conversion step in photosynthesis consists of an electron transfer from a chlorophyll species to an acceptor located within a reaction-centre protein. This protein functions as a very efficient solar cell converting sunlight to electrical energy. The plant then uses this energy to drive the slow biochemical reactions which ultimately yield the products of photosynthesis. Our project aimed to synthesize linked donor-acceptor molecules which would mimic the photochemical electron transfer reaction of photosynthesis. As a donor we chose the porphyrin ring which is similar in structure to that of chlorophyll, and as an acceptor we chose benzoquinone which is the central unit of plastoquinone, a natural acceptor in photosynthesis. In our project we studied the various factors which influence the electron-transfer efficiency in these molecules, factors such as the distance between the donor and acceptor relative to the donor, solvent, and the degree of unsaturation in the linkage between the donor and acceptor.

As a result of our work we now have a clear understanding of the importance of these factors. In particular, we have demonstrated a striking dependence on solvent and on the nature of the linkage. This opens up the possibility to design molecules containing groups of high or low "conductivity" as regards their ability to transmit electrons through a molecular system.

We have carried out preliminary experiments which demonstrate that we are able to couple the photoelectrons from these donor-acceptor molecules into the outside world by depositing monolayers on tin dioxide coated glass slides. This opens up the potential for the development of an ultrathin solar cell. Unfortunately, this will probably not take place because this project has been terminated by NSERC.

The following is a selection from a total of 30 publications resulting from this project in three years.

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J.R. Bolton, T.-P. Ho, S. Liauw, A.R. McIntosh, A. Siemiarz, C.S.K. Wan and A.C. Weedon, "Light induced intramolecular electron transfer from a porphyrin linked to a p-benzoquinone by a rigid spacer group". *Chem. Comm.*, 1985, 559.

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J.E. Guillet, Y. Takahashi, A.R. McIntosh and J.R. Bolton, "A new polymeric model for the active site in artificial photosynthesis", *Macromolecules*, 1985, 18, 1788-1790.

A.R. McIntosh, J.R. Bolton, J.S. Connolly, K.L. Marsh, D.R. Cook, T.-P. Ho, and A.C. Weedon "EPR and optical evidence for two distinct porphyrin triplet states in linked porphyrin-quinone molecules" *J. Phys. Chem.*, 1986, 90, 5640-5646.

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 Title of Project/Titre du projet: Clay Treatment and Stabilization Studies for Enhanced Oil Recover

The hydration, dehydration and rehydration of expandable and nonexpandable clays, the synthesis of new solid phases, the absorption of bitumen, inorganic compounds, polymers and surfactants and the role of these processes in clay stabilization under enhanced crude oil and bitumen recovery techniques using EPR, NMR, FTIR, XRD and X_3 spectroscopy has been studied. It has been shown that an irreversible hydration phase transition exists in the smectite clay, Ca-montmorillonite, which is found in small but significant quantities in most Alberta and Saskatchewan oil and heavy oil reservoirs as well as tar sands reserves. Consequently, the use of steam injection as a technique for enhanced recovery may not be as efficient as believed presently since the irreversible swelling of the smectite clay may decrease the porosity of the reservoirs so that the total amount of oil extracted has been decreased rather than increased. A new method of determining magnetic field gradients using rapid-scan NMR has been developed. It has been demonstrated that EPR measurements of asphaltenes that the g- and A-parameters cannot be correlated with the heteroatom content as previously believed.

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- (i) Malhotra, V.M. and H.A. Buckmaster (1985). "34 GHz EPR Study of Vanadyl Complexes in Various Asphaltenes: Statistical Correlative Model of the Coordinating Ligands" Fuel 64, 335-341.
- (ii) Malhotra, V.M. and H.A. Buckmaster (1985). "9 and 34 GHz EPR Study of the Free Radicals in Various Asphaltenes Statistical Correlation of the g-Values with Heteroatom Content". Organic Geochemistry 8, 235-239.
- (iii) Kubiak, J., Duczmal, T. and Buckmaster, H.A. (1986). "The Determination of Magnetic Field Gradients by Fast-Scan NMR Spectroscopy". J. Phys. E: Sci. Instrum. (in press. Accepted 1986/12/).

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- (i) Malhotra, V.M. and H.A. Buckmaster (1984). "The Behaviour of Free Radicals and Vanadium in Cold Lake Asphaltene Under Dry Combustion Conditions". American Chemical Society Division of Petroleum Chemistry. Preprint Series 29(4), 1232-1236. Proceedings of the 118th National ACS Meeting, Philadelphia, PA, U.S.A., Aug. 26-31, 1984.
- (ii) Malhotra, V.M. and Buckmaster, H.A. (1985). "The Behaviour of Minerals in Cold Lake Oil Sands Under Dry Combustion". Appl. Clay Science 1, 225-236. Proc. Symposium on Clay Minerals in Agriculture, Industry and the Environment, Calgary, AB, August 23-25, 1984.
- (iii) Buckmaster, H.A. and Duczmal, T. (1987). "The Interpretation of EPR Spectra Using Argand Diagrams". "Electronic Magnetic Resonance of the Solid State". Ed. J.A. Weil. Proceedings of ICC/CIC '86 Saskatoon Symposium "Electronic Magnetic Resonance of the Solid State". Saskatoon, SA June 1-4, 1986 (to be published by the Chemical Society of Canada).
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Title of Project/Titre du projet: Studies on Physico-Chemical Forms of Neptunium in Groundwater.

Large quantities of highly toxic and very long-lived radioactive waste products are generated by the processing of spent fuel of nuclear power reactors. The safe management of this waste requires its isolation from man and his environment for thousands of years. The ultimate isolation of vitrified high-level waste in deep geologic formations is being considered in several countries including Canada. Under an accidental scenario, the transport of radionuclides leached from the waste form by groundwater across the natural geochemical barrier is a potential risk. Formations such as clays are capable of quantitative retention of cationic species of a radionuclide whereas the anionic species can have considerable mobility; and a number of anionic species of a given radionuclide could be formed by interaction with the constituents of groundwater, in particular carbonate ions which are present in high concentrations.. Among the radionuclides present in high-level waste, ^{237}Np is of particular interest because of its acute toxicity, long half-life and considerable migration potential. The objective of this project is to characterize the anionic carbonate complexes of Np(V) under simulated geologic repository conditions.

In order to achieve the above objective, it was necessary to first undertake a series of developmental work. For example, significantly improved radiochemical separation methods were developed to prepare radiochemically pure ^{239}Np and ^{237}Np for use in latter experiments. These involved milking of ^{239}Np from ^{243}Am using solvent extraction with TTA, and separating ^{237}Np from ^{233}Pa using an ion exchange resin in presence of a mixture of halogenated acids. Solutions of neptunium nuclides were then converted to Np(V) by repeated evaporations with very dilute solutions of perchloric acid and finally with water. In order to ascertain the oxidation state of Np in this solution, a variety of methods were used. A new scheme consisting of solvent extraction with 1-nitroso-2-naphthol in butyl alcohol, ion exchange separation with Dowex 50X8 and coprecipitation with lanthanum hydroxide was developed for separating different oxidation states in an alkaline medium. The results showed that the tracer solutions contained Np(V) state only. Experiments were then carried out to study the carbonate complexes of Np(V) . Due to the low ionic potential of Np(V) in NpO_2^+ , its carbonate complexes could not be satisfactorily investigated using solvent extraction with a single chelating agent under simulated geologic repository conditions. Among the various synergistic chelating systems examined, the TOMA-TTA adduct was most suitable for studying the neptunium(V) carbonate complexes. Consequently, a liquid-liquid extraction method involving TOMA-TTA was developed and its extraction mechanism studied. Experimental data were then mathematically modeled to identify the possible Np(V) carbonate species and to calculate their conditional formation constants. At an ionic strength of 0.2 M, carbonate alkalinity between 4×10^{-3} M and 1×10^{-2} M, and Np(V) concentration between 1×10^{-14} M and 1×10^{-12} M, the predominant species were identified as $\text{NpO}_2\text{CO}_3^-$ ($\log \beta_1 = 4.10 \pm 0.02$) and $\text{NpO}_2(\text{CO}_3)_2^{3-}$ ($\log \beta_2 = 7.00 \pm 0.04$). A speciation diagram of Np(V) at a pH of 8.5 and an ionic strength of 0.2 M was then constructed. It is evident that despite the low ionic potential, Np(V) could form carbonate complexes of relatively high stability constants. Since both the predominant species are anionic, they have the potential to migrate through the host clay formation in a geologic repository. A third anionic species, namely $\text{NpO}_2(\text{CO}_3)_3^{5-}$, could become important at higher carbonate concentrations and pH.

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Title of Project/Titre du projet:	Evaluation of Electrocatalysts for Water Electrolysis and H ₂ /O ₂ Fuel-Cells

In recent years, a strong interest has developed in Canada in the production of hydrogen, especially by the electrolytic route using our extensive hydro-electric resources. Corresponding activity in its use in the chemical and petroleum industries, and for local regeneration of electric power through fuel cells, has arisen.

The energy efficiency with which electrolytic H₂ can be prepared is determined by the cell voltage required to pass the necessary current for H₂ generation in relation to the thermodynamic minimum decomposition voltage (1.23 V) for water under reversible conditions. Practical decomposition voltages for high rates of electrolysis may be much above the 1.23 figure due to polarization or overvoltages ΔV at the H₂ cathode and O₂ anode.

Our project has been concerned with developing and evaluating new active cathode and anode materials for alkaline water electrolysis that have good "electro-catalytic activity" for the electrolysis processes involved. Especially, we have sought and found materials that give a low rate of change of overvoltage with the logarithm of current density, i . Polarization at electrodes is characterized by a dependence of ΔV on $\log i$ with a slope, b . With some Ni + Mo preparations we have achieved electrolysis with b as low as 0.025 V (compared with the normal value on many other metals of 0.12 V) and $\Delta V \leq 0.1$ V at $i \approx 200$ mA cm⁻².

A new method of characterizing electrocatalysts for water electrolysis by determination of the coverage behaviour of the adsorbed H and OH or O intermediates was developed that enables the factors giving low-slope behaviour, desired for good energy efficiency, to be evaluated. These results led to realization of the importance of hydride-phase involvement in good cathode materials for electrolyzers and in active anode materials for fuel-cells. The Ni-Mo materials are suitable for industrial use and are easily prepared. Electrodeposited Pt+Pd composites, in an hydrided condition, were also found to behave well as electrolyser and specially as fuel-cell electrode.

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Title of Project/Titre du projet: Numerical Simulation of Fractures for Hydrocarbon Recovery

SUMMARY

Artificially created hydraulic fractures play a central role in the recovery of the hydrocarbon values contained in Canada's major hydrocarbon deposits: the tight gas deposits of Alberta and British Columbia and the oil sands of Alberta. In the present work, mathematical models were developed to simulate fractures, particularly relevant to the above situations.

In the context of tight gas reservoir fracturing, the ability to create bounded vertical fractures is critical to the success of a fracturing operation. We have shown using numerical and analytical models that vertical variations in rock modulus do not affect the vertical growth of fractures. Vertical extent is controlled entirely by vertical variations in tectonic stress. We have developed a straight forward method of locating the upper and lower crack tips using an analytical procedure.

As part of the work, an optimization study was carried out to determine the most cost effective fractures for tight gas reservoirs. We found that wells should be fractured to a dimensionless conductivity of 4.2 under all reservoir conditions. For one case study it was shown that the present value of a well could be increased by \$0.35 million by fracturing to the optimal conductivity rather than a value as high as 10. Fracture conductivities higher than 100 are generally reported in the literature.

Significant advances have been made in developing numerical and analytical methods for determining the behaviour of fractures near bimaterial interfaces.

In the context of oil sands fracturing and deformation, we have undertaken the development of a generalized boundary integral numerical method that will permit the simulation of the simultaneous fracturing and plastic deformation that occurs during thermal recovery operation. Analytical and numerical methods have been developed to overcome the limitations of the existing boundary integral methods.

Associated Publications

1. R.L. Fung, S. Vijayakumar and D.E. Cormack, "The Calculation of Vertical Fracture Containment in Layered Formations", Soc.Pet.Eng.J., in press.
2. S. Vijayakumar and D.E. Cormack, "Green's Functions for the Biharmonic Equation: Bonded Elastic Media", SIAM J. on Applied Mathematics, in press.
3. S. Vijayakumar and D.E. Cormack, "Nuclei of Strain for Bimaterial Elastic Media with Sliding Interface", J. of Elasticity, in press.
4. S. Vijayakumar and D.E. Cormack, "Canonical Representation of Influence Functions in Elastic Media", Mech. Res. Com., in press.
5. S. Vijayakumar and D.E. Cormack, "On the Evaluation of Singular Integrals", Com. in Appl. Num. Meth., in press.
6. D.A. Payne and D.E. Cormack, "Optimal Fracture Design for Tight Gas Reservoirs", J.Can.Pet.Tech., submitted for publication (Apr. 1986).
7. D.E. Cormack and P.M. Vallance, "A Numerical Method for Computing Axisymmetrically Loaded Cracks", J. of Appl. Mechanics, submitted for publication (June, 1986)
8. S. Vijayakumar and D.E. Cormack, "Differential Geometric Foundation of the Boundary Element Method", Mech.Res.Comm., submitted (Aug. 1986)
9. R.K. Fung, "Modelling of Dynamic Fracture Propagation and Fracture Containment During Vertical Hydraulic Fracturing" MASC (1985)
10. D.A. Payne, "The Design of Vertical Hydraulic Fracture Stimulations for Tight Gas Reservoirs", MASC. (1986)
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12. S. Vijayakumar, "Development of Analytical and Numerical Tools in Elasticity", PhD. (1987)

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Title of Project/Titre du projet: Cellules photovoltaïques et photoélectrochimiques à base de semiconducteurs organiques électropolymérisés.

Le futur de la conversion photovoltaïque de l'énergie solaire comme source alternative d'énergie dépend largement du développement de matériaux photoactifs à grande surface et bon marché. Les matériaux semiconducteurs organiques ont le potentiel de répondre à ces exigences. L'efficacité solaire des cellules photovoltaïques et photoélectrochimiques organiques est encore faible; celle-ci est due à la faible efficacité quantique, à la courte profondeur de la zone de déplétion, à la faible corrélation entre le spectre solaire et le spectre d'absorption du semiconducteur organique et surtout à la grande résistivité de ce dernier.

Afin d'améliorer l'efficacité des cellules solaires organiques, nous avons, dans le cadre de ce projet, a) entrepris la synthèse et la modification de semiconducteurs organiques hautement colorés afin de les rendre absorbants entre 400-900 nm, b) greffé ces derniers sur des monomères de dérivés de pyrroles et de thiophènes, c) polymérisé électrochimiquement sur des électrodes transparentes (ITO) et métalliques (Pt, Au) pour obtenir des films minces et uniformes de polymères conducteurs aromatiques hétérocycliques modifiés. Les électrodes modifiées résultantes présentent des activités photovoltaïques et électrocatalytiques. Des cellules photovoltaïques et photoélectrochimiques à base de ces nouveaux matériaux sont ensuite préparées et caractérisées.

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3. G. Perrier, L.H. Dao, "Cellules photoélectrochimiques de phthalocyanine d'hydroxyaluminium déposées par rotation", Can. J. Chem. 64, 2431-39 (1986).
4. G. Perrier, L.H. Dao, "Improvement of the performance of an hydroxyaluminium phthalocyanine photoelectrochemical solar cell by a phthalate treatment", J. Electrochem. Soc. 134, in press (1987).

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Title of Project/Titre du projet: Nuclear and Conventional Energy Production and Transmission Systems Reliability and Safety Assurance Methods.

The main objective of this study was to investigate nuclear and conventional energy production and transmission systems reliability and safety assurance methods. The study was divided into three phases. The first phase was concerned with reliability parameters in equipment design specifications, developing reliability models and collecting published literature. The second phase was directed toward reliability and maintainability management during the equipment design and operation phases, developing mathematical models, and reliability evaluation of systems with human error and common-cause failures. The last phase was primarily concerned with developing concepts to predict equipment reliability in alternating environments, developing and simplifying reliability evaluation techniques, and performing human reliability analysis. Due to space limitation, only some of the publications resulted from this study are listed below. The complete list is available from the investigator.

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Title of Project/Titre du projet: Development of a New Core Analysis

Reservoir core sample analysis is an essential tool utilized by the oil industry in evaluating and developing petroleum reservoirs. The core analysis results are used by the oil industry in assessing the amount of oil in a given reservoir, in deciding which oil recovery process to use, and in predicting process performance. Current techniques, using oil and brine, involve lengthy, fairly difficult two-phase flow experiments. There is no provision to allow simultaneous measurement of more than one property of a particular test sample. Repeat two-phase flow experiments are seldom done on a given sample at one and the same saturation.

The new core analysis technique developed incorporates the following measurements on the same sample under the same saturation conditions and allows simple and rapid repeat measurements: relative permeabilities, formation resistivity indexes, and dispersion coefficients for each phase, capillary pressure curves, and, for each phase, the distribution of the fluid between flow channels from which it can be easily displaced, and stagnant zones created by the blocking action of the other phase, from which displacement is slow and difficult. Immiscible displacements are done at constant capillary pressure to establish a uniform saturation and then one of the phases is solidified. The non-solidified phase space can then be characterized by simple single phase flow experiments which can be repeated as often as desired using any convenient fluid. Then, a second solidifiable material is injected into the phase space of a small piece of the sample and solidified. Qualitative or computer-aided quantitative 2-or 3-dimensional investigation of the distribution of the phases within the sample can then be made by observation of thin sections or serial sections. The new core analysis has been demonstrated using Berea sandstone cores, cores from two Alberta oil fields, and cores from an Ontario oil field.

Advantages of the new core analysis over the current techniques include: increased reliability of data resulting from repeat measurements of important parameter values, more reliable evaluation of the relationship between pore structure and transport properties and new information on phase distributions at specific saturations.

Specific accomplishments of the Strategic Grant research include: a) the first direct measurements of the stagnant fraction of each phase as a function of saturation; b) the first analysis to show how to evaluate data from sets of 2-dimensional serial sections of small samples to correctly compute the 3-dimensional connectivity of the pore space of the large homogeneous medium; c) the first validated automatic computer analysis of 3-dimensional connectivity; and d) the first identification of individual pores and pore necks and their locations in a sample. Much of the computer reconstruction software developed will have applicability to problems in any area of engineering, biology, medical research, etc. involving irregular, 3-dimensional networks.

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 Title of Project/Titre du projet: ENHANCED OIL RECOVERY USING LIGNIN WASTE PRODUCTS

The principal outcome of this research program has been a greatly improved understanding of how lignosulfonates (wood-based surfactants) can assist in the recovery of oil from partially depleted petroleum reservoirs. We have found that they can interact synergistically with the commercially popular (but expensive) surfactants, such as petroleum sulfonates, to produce ultra-low interfacial tensions between oil and water, while at the same time lessening the amount of commercial surfactant required. Specific fundamental studies have included an assessment of the effects of divalent ions (which occur naturally in petroleum reservoirs) and the effects of temperature on interfacial tension and on coalescence behaviour. During the last two years, some new research directions evolved in consequence of the successful attainment of the original objectives. In particular, we have been pursuing a study of the spontaneous instabilities that occur whenever a more viscous fluid (oil) is being displaced from a porous rock by a less viscous fluid (water). We have also become actively interested in the recovery of heavy oil from the vast reserves thereof in Western Canada. Each of the above mentioned projects has resulted in several publications, a list of which follows:

Lignosulfonate Studies:

1. Manasrah, K., G. Neale & V. Hornof, "Properties of mixed surfactant solutions containing petroleum sulfonates and lignosulfonates", Cell. Chem. and Tech., **19**, 291-299 (1985).
2. Kumar, A., G. Neale & V. Hornof, "Effects of connate water ionic composition on coalescence of oil droplets", J. Coll. Int. Sci., **104**, 130-135 (1985).
3. Kumar, A., G. Neale & V. Hornof, "Some effects of temperature on interfacial tension between hydrocarbons and surfactants", Colloids and Surfaces, **14**, 11-20 (1985).
4. Babu, D., G. Neale & V. Hornof, "Potential use of lignosulfonates and spent sulfite liquors in petroleum recovery", Cell. Chem. and Tech., in press (1987).

Instability Studies:

5. Hu, M., V. Hornof & G. Neale, "Visualization of unstable miscible radial displacements in a consolidated porous medium", Powder Tech., **41**, 265-268 (1985).
6. Ni, L., V. Hornof & G. Neale, "Radial fingering in a porous medium", Revue de l'institut français du pétrole, **41**, 217-228 (1986).

Heavy Oil Studies:

7. Khulbe, K., V. Hornof & G. Neale, "Interfacial activity of heavy oil and its maltene components against caustic solutions", AOSTRA J. Research, **2**, 95-101 (1985).
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Name/Nom: Dr. F. Hron and Dr. M. Razavy
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 University/Université: University of Alberta
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 Title of Project/Titre du projet: Computer Inversion of Geological Data Using Inverse Methods and Direct Forward Modelling

Dr. F. Hron (a) *Automatic inversion of seismic data using the extensions of the Gel'fand-Levitan theory.* During the first two years of the tenure of the grant a considerable amount of time was devoted to the development, testing and application of computer software for the automatic interpretation of the acoustic wave field following the method proposed by Hooshyar and Razavy (1983a,b). Their method employs reflection data obtained for acoustic plane harmonic waves impinging on interfaces at different angles of incidence. Hence, the so called plane wave decomposition must be used when the method is applied to wave fields radiated from highly concentrated seismic sources which are characterized by diverging wavefronts. The results of our numerical experiments in this area showed that the most significant source of inaccuracies in the numerical procedures was the accumulation of round-off error in the continued fraction expansion employed in the Hooshyar-Razavy method. The successful implementation of our program required a very small spatial step in the vertical direction where a finite difference computation scheme was employed in the solution. This in turn dictated that the input data be extremely detailed which is not generally available under normal field data acquisition techniques in the oil exploration industry. This fact makes the use of this method rather difficult for routine application in the processing of standard seismic data.

(b) *Linearized inversion of travel times and ray amplitudes.* In our iterative program for inversion we have successfully combined the Singular Value Decomposition algorithm with Asymptotic Ray Theory. Our total inversion process has been designed to work in two steps: (a) inversion of the kinematic data, and (b) inversion of the dynamic data under the constraints inferred from the traveltimes. The kinematic inversion stage computes the P wave velocities, V_p , and the layer thicknesses from the travel time data. These velocities are then used to form the part of the initial estimate required for the inversion of the dynamic information. As a good initial guess is very important for fast convergence, the use of this information from step (a) significantly improves the convergence rate in step (b). S wave velocities, V_s , and the densities, ρ , are not available from the travel time inversion in step (a). Two different approaches, (a) the stripping method, and (b) the simultaneous full model inversion have been tried as inversion schemes. In the stripping process each layer is considered separately, starting from the topmost layer. In the full model inversion approach, all of the model parameters are computed simultaneously. In this case, the transformation matrix A contains information from all the specified arrivals and includes the effects of all the model parameters and the data recording sites. Therefore, it is obvious that the matrix dimension will be substantially larger than in case (a). The stripping method has been found to be more convenient than the full model simultaneous inversion scheme in terms of storage requirements, total processing time and convergence, and the final results of both methods are essentially the same. Unfortunately, the program still requires a great amount of expertise to run and needs a considerable amount of grooming before it becomes "user friendly", producing high quality output in graphical form demanded by industrial users. The easiest way of accomplishing this would be with the assistance of a professional programmer who specializes in computer graphics and is familiar with the program. Preliminary results using our program have been communicated in the following series of papers (Shahriar et. al. (1986) and (1987) and Hron et. al. (1987)) which are in the process of being published.

Dr. M. Razavy The inverse problem of elastic wave propagation in an inhomogeneous medium is formulated as a finite continued fraction expansion for (a) the case of normal incidence, (b) two dimensional propagation with velocity varying with depth, and (c) for three dimensional wave motion where the elastic parameters are functions of radial distance. This method is stable with respect to changes in the input data and the termination of the continued fraction, but apparently is sensitive to the accumulation of errors. The solution can be expressed in terms of finite differences obeying the Reciprocity Principle or violating it. It has been shown that the violation of this principle is not an indication of the accuracy of the approximation.

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In addition 16 oral communications were given on this and related subjects, six of which were invited.

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Title of Project/Titre du projet:

Compositional Characterization of Combustion
Condensate Particulates From Energy Sources

Studies have been completed on the chemical and physical characterization of particulate matter emitted to the atmosphere from large scale sources such as coal-burning energy plants, industrial power plants, and municipal incinerators in comparison with other dominant sources of particulate emissions in urban atmospheres comprising mixed light industry and residential locales. Photon and thermal neutron activation analysis were used to determine the concentrations of up to thirty elements in aerosol samples collected by cascade impactor in Toronto, Canada during the period July, 1984 to the summer of 1986. For the purpose of physical characterization of combustion condensate particulates to distinguish matter emitted by such sources from particles arising from wind-entrained dusts and fugitive emissions from light industry and construction activities, the particles collected on each stage of the cascade impactor, particle size-sorting air samplers, were analyzed by scanning electron microscopy (SEM). The resulting electron photomicrographs allowed a clear distinction between high-temperature combustion condensates such as coal flyash particles, characteristically appearing as smooth-sided spherical, sub-micron particles, from other atmospheric particles of an irregular shape and wider size distribution. (Examples of these particle size patterns and the efficiency of the cascade impactor stage-by-stage size sorting, are provided in the final report). These investigations together with the multielemental analysis of 30-40 inorganic constituents collected on each sampler stage represented the achieving of the first objective of the research project as originally proposed. Examination of the resulting particle-size correlated elemental concentration patterns made possible the development of a new receptor model. The model, referred to as a size-specific elemental mass balance (SSEMB), was used to apportion the mean ambient aerosol concentrations amongst 4 to 6 contributing sources, including: coal-burning plants, motor vehicle exhausts, refuse incinerators, contributions from local light industry, and wind-entrained dusts. The concentrations of elements such as Al, As, Br, Na, Pb, Sb, and Zn predicted by the new SSEMB version of a chemical element balance model as representing the summation of these 4-6 emission sources of known trace elemental profiles, agreed with observed concentrations to within a factor of two or better for most elements in most particle size fractions and this was considered to be quite acceptable considering the large number of variables involved and the limitations in the precision of the concentration data for some trace elements in the various size ranges. Through a judicious use of this set of non-destructive radioanalytical, multi-elemental measurement techniques and by subjecting the resulting large mass of elemental concentration data to statistical factor analysis and chemical element mass balance modeling, adjusted to take into account aerosol particle size characteristics, it has been possible in the latter stages of this study, to apportion the relative contributions to the airborne particulate matter concentrations from prominent local emission sources, including some dominant combustion sources, at several different urban sites, with quite good reliability. Finding a means to make use of particle size distributions from different contributing sources has been a unique development in these NSERC-supported studies and this was one of the important objectives of this strategic grant project.

☐ Biotechnology
Biotechnologie
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Alimentation-Agriculture

☐ Communications and Computers
Télécommunications et informatique
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Matériaux et procédés industriels

☒ Energy
Énergie
☐ Oceans
Océans

☐ Environmental Technology
Technologie de l'environnement
☐ Open
Ouvert

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Title of Project/Titre du projet: "THE COMBUSTION OF GASEOUS FUELS CONTAINING SIGNIFICANT AMOUNTS OF DILUENTS"

It was found that the stability of a jet diffusion flame such as in a flare or a burner, can be enhanced significantly through the presence of very small concentrations of a fuel in its surroundings. The concentration of the latter fuel needs to be well below its corresponding lean flammability limit in air. This phenomenon can be exploited, not only to improve the flame holding characteristics of burners under adverse flow conditions, but also aid the combustion of gaseous fuels that are difficult to burn conventionally due to their containing excessive amounts of diluent gases such as nitrogen and/or carbon dioxide. This concept was incorporated in the design of a simple model burner that produced around the main fuel jet discharge, a sheath of a localized atmosphere of fuel-air mixture. Various geometrical configurations for such a burner were tested and pointers were obtained regarding the optimum design.

It was demonstrated that improvement to the jet flame blowout limit could be achieved when the fuel contained significant proportions of diluents such as nitrogen, through the expenditure of some auxiliary fuel in the surroundings of the main jet. For example, for the same configuration and size of burner, in excess of twice the normal volume of the limiting amount of fuel can be burned without loss of flame relative to the conditions where no auxiliary fuel was employed, for a fuel containing up to 77% nitrogen and 23% methane by volume. Increases in the maximum rate of energy release by the burner was throughout very significantly higher than the energy expenditure represented by the auxiliary fuel. Moreover, in tests of the model burner in a wind tunnel with varying intensity of cross wind, it was demonstrated that the flame blowout characteristics were also enhanced significantly by employing the auxiliary fuel.

It was shown that as long as stable burner flames were involved, the combustion efficiency for both the main and auxiliary fuel systems was very high and consistent with that expected normally from a well designed and operated conventional burner. However, once flame instability sets in, then the combustion efficiency deteriorates quite significantly.

The burner tested was necessarily of extremely small size (1-4 mm main jet diameter), while industrial burners or flares represent orders of magnitude larger sizes. There is a need to carry out further research that would investigate the consequences of the scaling up of such a design.

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Title of Project/Titre du projet: Flow In Small Centrifugal Fans

Small (about $\frac{1}{2}$ HP) centrifugal fans are extensively used in forced air heating systems in Canadian residences. They are also used in other air-moving applications where small air flow rates at moderate static pressures are required. The impellers of these fans differ in a number of significant respects from those of larger centrifugal fans: the width to diameter ratio is relatively large, the trailing edges of the blades are usually forward facing and a large number (typically about 50) of short-chord closely spaced blades are used. The latter feature gives rise to the term, "squirrel-cage fans", for the machines. Their peak efficiency is generally low (typically about 55%), and the flow phenomena in them are very complex and poorly understood. Improvements of their efficiency would lead to substantial energy savings.

A commercial squirrel-cage fan was modified for test purposes. Performance measurements were made for a variety of impeller and casing configurations. Detailed measurements of velocity components and pressures were also made in the flow entering and leaving the impeller. These measurements revealed very complex flow patterns, especially when the fan was operating at off-design conditions. There were many situations where air flows backwards through some portions of the impeller, that is from the casing back into the inlet region. The flow behaviour is still only poorly understood but it is apparent that flow in one part of the fan depends a great deal on what is happening in other parts of the fan. For example, the pressure distribution in the casing which collects the flow has a strong influence on flow through the impeller blades. A mathematical analysis is being developed in an attempt to better understand how flow conditions in one part of the fan influence flow conditions elsewhere.

This research will continue. The goal is to gain an understanding of the flow behaviour and to use this understanding to devise cost-effective design improvements.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

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|---|--|---|---|
| ☐ Biotechnology
Biotechnologie | ☐ Communications and Computers
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Matériaux et procédés industriels | ☐ Oceans
Océans | ☐ Open /
Ouvert |

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Title of Project/Titre du projet: PORTABLE DATA ACQUISITION AND DIAGNOSTIC FACILITY FOR
ELECTRIC ARC FURNACE DISTURBANCES

The general purpose of this project was to develop a flexible and portable data acquisition and diagnostic facility for applications where the three phase electrical supply voltage and current waveforms have a significant, randomly varying harmonic content. The specific end-use application was to develop means and methodology to measure a broad range of electric arc furnace disturbances and parameter variations. The general and specific objectives of the project were fulfilled with the major contributions including the following:

(a) Measurements made on two 65 MVA and one 100 KW electric arc furnaces were used to undertake the first fundamental study of the statistical properties of furnace disturbances and parameter variations. It was found that the time variations of a broad range of parameters (eg. rms voltages and currents, real and reactive power, furnace phase resistance and reactance) could be treated as weakly stationary random processes, with weakly Gaussian probability density functions, for periods of operation as long as 6 min. during scrap melting. Two strategies that could be reliably used to measure the mean and standard deviation of the cycle-by-cycle parameter variations on-line, in real-time, were developed. It was shown that previously used methods would yield results that were significantly in error.

(b) Two specific hardware configurations to measure the furnace data and parameter variations were implemented and tested. The first used a MICRO PDP 11/23 22-bit Q-bus system with 10 MB Winchester, 1 MB of memory and data acquisition via an 8 channel, differential input, commercially available A/D board having a total rated throughput to memory of 200 kHz. Software for the interactive analysis and graphical display of the acquired data was developed for the arc furnace application. Commercially available software was used to control the A/D conversion process.

(c) A low cost, intelligent module suitable for remote data acquisition applications was also developed. The module was based on the industrial standard 8-bit STD-bus and incorporated a specially designed A/D conversion card and intelligent controller. The card allows up to 6 channels to be sampled simultaneously with an aggregate rate in the order of 100 kHz. The sampling rate, channel sequence and channel gain are set under software control. Software was developed to allow the system to be remotely booted, configured, and interrogated; the acquired data can be processed locally or can be transmitted to a local or remote computer. This system is well suited for a broad range of applications.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology /
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☐ Oceans /
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☐ Environmental Toxicology /
Toxicologie de l'environnement
☐ Open /
Ouvert

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Title of Project/Titre du projet: Application of inclined plate settlers to separation of bitumen-sand slurry.

The project dealt with simple and ideal systems. We used light particles to simulate bitumen droplets and heavy particles to simulate sand. A salt solution was used as the suspending medium. When a mixture of light and heavy particles are allowed to separate in a vertical tube, the light particles rise while the heavy particles settle down the tube. At high solids loading, above 20%, it was observed that the light particles and the heavy particles form aggregates that would rise or settle together. This gave an increase in the overall settling/rise rate. Such a phenomenon is referred to as "fingering".

In the past, settling of a suspension (say heavy particles in a liquid) in an inclined tube was found to enhance the settling rate of the heavy particles. Similarly we found that the separation of light and heavy particles is also enhanced using inclined plates settlers. In this respect we found that at high solids loading the fingering phenomenon mentioned earlier also occurs.

The increase in the separation of the light and heavy particles was found to depend on the angle of inclination of the inclined parallel plates and on the concentration of both the light and heavy particles. At low solids loading, the separation rate enhancement increased with the angle of inclination. However, at high solids loading the maximum separation enhancement was at an inclination angle of about 15° from the vertical.

In the low solids loading range a mathematical model was developed, the model describes the separation process quite faithfully.

SUMMARY FOR PUBLICATION/RÉSUMÉ À PUBLIER

FIELD OF RESEARCH / DOMAINE DE RECHERCHE

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| ☐ Biotechnology /
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Océans | ☐ Open /
Ouvert |

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Title of Project/Titre du projet: The Utilization of Planar Magnetron Sputtering: Thin Films
for Solar Energy Applications

A new production process based on so-called "PLANAR MAGNETRON SPUTTERING" has been developed for the fabrication of new heat-reflecting coatings on flexible glazing such as polyester film. When applied to windows, these coating significantly improve the insulating performance of a window, which usually accounts for major heat loss in a building.

Several new types of heat-reflecting coatings have been identified. Accelerated lifetime tests have shown that a multilayer structure consisting of two dielectric layers with a metal layer sandwiched between the dielectric layers will provide excellent heat conserving properties for at least 20 years.

The basic physical mechanisms associated with the high rate, reactive sputtering process used to fabricate the heat-reflecting coatings have been better understood through a systematic study of the thin film properties as a function of sputter process parameters. The crucial process factor was the application of an radio frequency voltage to the substrate during thin film deposition.

The research results have been successfully transferred to Canadian industry for commercialization. Two spin-off companies have been created as a result of the applied research.

Three Ph.D. theses, two M.Sc. theses, nine publications, three patents, and numerous university/industrial contacts were generated from the Strategic Grant support.

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Title or Project/Titre du projet: Effets des basses températures sur les systèmes de refroidissement utilisés dans les réseaux électriques

Le projet comporte trois volets 1° l'étude de la condition thermique à flux constant qui est celle de la partie chauffante d'un transformateur électrique, 2° l'étude de la convection dans un thermosiphon fermé, 3° l'étude de l'effet d'une viscosité variable avec la température sur la couche limite. Les publications réalisées jusqu'à date concernent les deux premiers volets et s'appliquent à des conditions permanentes. Le dernier volet traite de conditions transitoires et fait l'objet d'une thèse de doctorat devant être terminée cette année.

- 1 VASSEUR, P. and ROBILLARD, L., "Brinkman Model for Boundary Layer Regime in a Rectangular Cavity with Uniform Heat Flux from the Side", *Int. J. Heat Mass Transfer*, (under press).
- 2 VASSEUR, P., ROBILLARD, L. and ANOCHIRAVANI, I., "Natural Convection in a Shallow Cavity Heated From the Side with a Uniform Heat Flux", *Chem. Eng. Commun.*, Vol. 46, pp. 129-146, 1986.
- 3 VASSEUR, P., ROBILLARD, L. and ANOCHIRAVANI, I., "Natural Convection in a Inclined Porous Cavity with Uniform Heat Flux from the Side", *Wärme-und Stoffübertragung* (under press).
- 4 SEN, M., VASSEUR, P. and ROBILLARD, L., "Multiple States for Unicellular Natural Convection in an Inclined Porous Layer", *Int. J. Heat and Mass Transfer*, (accepted).
- 5 VASSEUR, P., SATISH, M.G. and ROBILLARD, L., "Natural Convection in a Thin Inclined Porous Layer Exposed to a Constant Heat Flux", *Int. J. Heat Mass Transfer*, (under press).
- 6 VASSEUR, P., SATISH, M.G. and ROBILLARD, L., "Natural Convection in a Thin Inclined Porous Layer Exposed to a Constant Heat Flux", 8th Int. Heat Transfer Conf. San Francisco, Vol. 2, pp. 2665-2670, 1986.
- 7 ROBILLARD, L., NGUYEN, T.H. and VASSEUR, P., "Free Convection in a Two-Dimensional Porous Loop", *ASME J. Heat Transfer*, Vol. 108, pp. 277-283, 1986.
- 8 PRUD'HOMME, M., ROBILLARD, L. and VASSEUR, P., "A Study of Laminar Natural Convection in a Non-Uniformly Heated Annular Fluid Layer", *Int. J. Mass Transfer*, (under press)
- 9 ROBILLARD, L., NGUYEN, T.H., SATISH, M.G. and VASSEUR, P., "Oscillating Flow in an Annular Porous Layer Heated from Below", 1985 ASME/AICHE National Heat Transfer Conference, Denver, HTD-Vol. 46, pp. 41-47, 1985.
- 10 NGUYEN, T.H., SATISH, M.G., ROBILLARD, L. and VASSEUR, P., "Free Convection in a Non-Uniformly Heated Annular Porous Layer", ASME Heat Transfer Conference, Miami, 85-WA/HT-8, 1985.

☐ Biotechnology /
Biotechnologie
☐ Food-Agriculture /
Alimentation-Agriculture

☐ Communications and Computers /
Télécommunications et informatique
☐ Industrial Materials and Processes /
Matériaux et procédés industriels

☒ Energy /
Énergie
☐ Oceans /
Océans

☐ Environmental Toxicology /
Toxicologie de l'environnement
☐ Open /
Ouvert

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University/Université: University of Waterloo

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Title of Project/Titre du projet: Development of an Atmospheric Pressure Flash Pyrolysis Project

A fluidized bed atmospheric pressure process for the rapid conversion of biomass to liquids with yields as high as 75%-80% from poplar wood has been optimized in a small continuous test unit with a throughput of 3 kg./hr. of sawdust or other ground wood. The conditions of temperature, feed rate and particle size giving the maximum yields of liquids were determined. Yields of organic liquids are not affected by moisture contents to 25%.

A variety of biomass materials have been pyrolyzed, among them poplar, maple, spruce, wheat straw, corn stover, bagasse and peat. In general, the higher the cellulose content the better the liquid yield.

The pyrolysis oil can be used directly as a substitute fuel oil. Although its heating value is relatively low (a little higher than wood), it has a density of 1200 kg./m³, so that its volumetric heating value is much higher than that of wood. The oil can be burned successfully in conventional pressure atomizing oil fired equipment.

The product oils show the presence in considerable quantity of some interesting chemicals with commercial potential, such as acetic acid, hydroxyacetaldehyde and hydroxypropenone. Changes in operating conditions, and pre-treatment of the feed, can alter the relative amounts of these components significantly.

The pyrolysis oil can be readily separated into a fraction derived mainly from the lignin (about 30%), and a water soluble carbohydrate fraction (about 70%). The latter can be a source of chemicals or a possible substrate for fermentation.

The fluidized bed reactor has been successfully modelled and equations describing oil yields developed for wood. Mixing behaviour and scale-up parameters for "shallow" fluidized beds have been investigated experimentally and suitable reactor models developed.

The process could now be scaled to demonstration plant size (5 to 10 tonnes/day). Investigations are underway of applications for the oil, or for products separated from the oil. A preliminary economic feasibility study has been carried out.

The further successful development of the Waterloo Fast Pyrolysis process, whose basic concept has been copied by at least four other research groups, will lead to the establishment of industries to produce high value chemical specialties from waste biomass. Negotiations are currently underway on an initial licensing agreement of our technology to one company. In terms of the successful production of higher value commercial chemicals from biomass by economic methods, the Waterloo Fast Pyrolysis process is one of the most promising, if not the most promising, of current technologies which can contribute to this goal. A very large commercial potential now exists for this process.

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In addition, eight conference papers, and four theses, have been published, three patent applications have been filed and two papers have been submitted to refereed journals

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University/Université: Carleton University
Phone number(Optional)/N° de téléphone (facultatif): 613-564-2802
Title of Project/Titre du projet: Thermo-mechanical Interactions in a Nuclear Waste Disposal Vault Borehole"

The development of necessary containment technologies for the long term safe storage and disposal of immobilized high level nuclear fuel waste is an area of research which is of crucial importance both to the nuclear energy industry and to the environmental authorities. In Canada, the used fuel, which forms the main source of the high level nuclear waste, is currently stored in water pools at the thirteen active reactor sites. In some instances, wastes have accumulated over two decades of the safe operation of the reactors. The removal of the waste from the active reactor sites is considered an operation which would minimize the potential hazard of an unwarranted massive scale environmental damage in the event of a reactor accident. The Fuel Waste Technology Branch of Atomic Energy of Canada Limited is the lead agency for the development of containment technologies. The Canadian proposals for the disposal scheme specifically concentrates on the deep burial of the fuel waste in specially constructed vaults in plutons found in the Canadian Shield of Northern Ontario. The disposal scheme intends to isolate the waste forms from interaction with the geosphere and the biosphere throughout its harmfully active lifetime, which could span tens of thousands of years, by utilizing a series of engineered barriers. The engineered multi-barrier concept forms a key feature in the waste disposal effort. At the deep vault level these barriers include containers which house the spent fuel elements; a buffer region, consisting of a mixture of bentonite clay and sand, which isolates the waste containers emplaced in boreholes drilled into the base of the vault system; and a backfill which fills the disposal galleries. In the isolation process the buffer material plays an integral part. It should conduct the heat from the stored waste to the host rock, act as a barrier for the sorption of radionuclides released in the event of accidental container failure or its natural breakdown, isolate the container from detrimental deformations of the host rock, retard the corrosive effects of groundwater and possess the ability to swell during water uptake and heal cracks, separation zones, etc. which will occur in a moisture depletion cycle. The efficiency of the buffer in fulfilling these constraints can be assessed only by subjecting the buffer material to a variety of plausible adverse environments. This research project examines the thermo-mechanical performance of the buffer material, in a borehole environment, under conditions of heat flow and no moisture influx from the host rock. The laboratory simulation of the borehole environment utilizes the candidate buffer material compacted to the reference density and a model waste container which maintains a skin temperature at an extreme value of 150°C. It is found that although the buffer experiences thermo-mechanical damage in terms of shrinkage and cracking it maintains its integrity in terms of communication of waste heat from the container to the host rock. The heat induced moisture depletion patterns are measured at the termination of the experiment. The simultaneous flow of heat and moisture within the buffer region can be predicted, with a reasonable degree of accuracy, by appeal to a mathematical model.

Name/Nom: J.S. Sheasby
Department/Département: Engineering Science
University/Université: The University of Western Ontario
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Title of Project/Titre du projet: Direct Observations of Lubricated Wear

Copper, brass and steel pins were worn both dry and lubricated in single-pass sliding at low speed against chromium-plated glass. The chromium plating was thin enough to see through, allowing the general pattern of the wear to be observed while it was occurring. For comparison, pins were worn under similar conditions against glass, steel and chromium-plated steel countersurfaces. Steel pins were also worn under observation in oils of various formulations whilst the temperature of the wearing surfaces was raised. Changes in the appearances of the pins were noted and recorded by still and movie camera.

The wear surfaces produced were more complex tribologically than those formed in multi-pass sliding, usually changing with both the distance from the leading edge of pins and with the distance of sliding. The many different surfaces were classified into five types of behaviour that followed a logical sequence. The lubricated pin surfaces could usually be related to the associated dry conditions making boundary lubricated wear more varied and more severe than generally appreciated. In most of the wear modes accretions were a notable feature on the wearing surface and could contain material from the pin, countersurface and lubricant. The accretions formed first in the central parts of wearing surfaces. On further sliding some accretions formed into bands behind the leading edge and had little effect on wear particle formation from the pin. In other wearing combinations the accretions formed into prows that could damage the hardest countersurface.

The microscope-wear machine was an excellent device to discover and investigate these modes of lubricated wear.

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Department/Département: E. ENGI
University/Université: U of Alberta
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Title of Project/Titre du projet:

"Enhancement of Flame and Transport Processes in Plasma Plugs"

SUMMARY

The intensity of local turbulence produced in the vicinity of a plasma jet igniter has been measured by monitoring smoke plume dispersion and heat conductivity when the igniter is discharged in air. The results show that the scale and intensity of turbulence are of magnitudes which are sufficient to substantially increase flame speed in a combustible mixture, both by flame profile distortion and by transport enhancement within the flame front.

Similar measurements taken over wide ranges of variation of the discharge time and jet cavity dimensions show that the turbulence increases with decreasing discharge time and falls off markedly when the diameter to length ratio of the cavity exceeds 0.5.

High resolution temperature profiles of jet ignited flames confirm the critical influence of the electrically induced turbulence in increasing flame speed, while the detection and measurement of turbulence near conventional sparks reveals that electrically induced turbulence may be a much more common influence upon the early stages of combustion than previously thought.

Name/Nom: T.S. Sorensen

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University/Université: Calgary

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Title of Project/Titre du projet: A study of the chemical reactions occurring in the ligand products during thermal coking of bitumen

At the present time, bitumen upgrading involves thermal coking (Suncor and Syncrude plants producing about 2×10^5 barrels/day of "syn-fuel"). In the process, nearly 20% of the crude bitumen is converted to a high sulfur coke of no real commercial value. In this study, we have investigated the effect of slurried additives (free-radical initiators, basic oxides, Lewis acids, metal compounds, e.g. of vanadium and nickel) on the coking reaction using model cokers. At the 5% weight of additive level, we found no cases where the amount of liquid products was significantly increased, although basic oxides appear to give a higher boiling and less attractive pyrolysate. Fractionation of the pyrolysates into the naphtha, diesel etc. boiling point ranges and the individual study of these as a function of additive showed some variation but we could not reliably show an improvement in the normally poor (high aromaticity) diesel fuel obtained from "syn-fuel". A study was also made of the hydrogen atom mobility taking place in coking by using deuterated pyrene as an additive. The results indicate very exhaustive hydrogen scrambling and lead one to conclude that many of the reactions are thermodynamically controlled and hence not readily influenced by additives (catalysts and retardants affect reaction rates but not equilibria). The major "mechanism" for hydrogen scrambling probably involves natural "hydrogen donor" molecules in the bitumen and we have evidence that extensive aromatization during coking probably occurs by such processes. An alternative to whole bitumen upgrading involves prior separation into maltene and asphaltene fractions and upgrading the latter using conventional hydrogen donor solvents (very similar to coal upgrading processes which have been extensively reported on). Slurried additives are also being used in this work, which is ongoing and which will appear in the published thesis of the graduate student involved (Martin Kirk).

Name/Nom: H. Tanaka* and Y. Lee**

Department/Département: *Civil Engineering, **Mechanical Engineering

University/Université: University of Ottawa

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Title of Project/Titre du projet: Air Infiltration of High-Rise Building for
Energy Calculation

Objective: Air filtration of a high-rise building is mainly due to the characteristics of the wind environment around the structure, the thermal gradient across the building envelope, and mechanical ventilation. The first two causes were found, through full-scale measurement, to be predominant. Following this measurement, three particular items have been studied experimentally and analytically as follows:

1. Wind tunnel testing to confirm and to complete the wind induced pressure differentials;
2. Study of non-linearity of pressure differentials and induced air infiltration under the combined effects of wind and mechanical ventilation; and
3. Prediction of the value of NPL (neutral pressure level) for calculation of stack effect for various wall temperature distribution and with and without internal partitions.

Achievement:

- A. The calculation of the values of NPL for buildings with multiple openings: Both experiment and analysis have shown that the stack effect equation (derived from the ideal gas equation of state for the uniform outside and inside temperature of a building) is accurate for the prediction of the pressure differentials induced by the stack effect, provided that the value of the neutral pressure level (NPL) is known correctly. The study demonstrated that the existing method recommended by ASHRAE is inadequate.
- B. Effect of internal partitions between floors on stack effect: The profile and distribution of pressure differentials depend also upon the floor partitions. Since the buildings in reality are neither completely open nor perfectly air-tight across the floor partitions, more realistic physical parameters should be introduced in the analysis. The effect of floor separation was found to be characterized by the ratio of the opening area in the floor partition to that of the external wall. Once the area ratio exceeds a critical value, the behavior of thermally induced pressure differential becomes the same as that of "open shaft" type buildings.
- C. The non-linearity of the combined action of stack effect and mechanical ventilation: An experimental study was made to determine the non-linearity of the combined action of stack effect and mechanical ventilation. The results showed that the combined effects can be given by simple linear summation for practical purposes.
- D. The Influence of Non-Uniform Temperature Distribution on Stack Effect: An analytical and experimental study has been made on the stack effect in high-rise buildings with and without internal partitions where the internal temperature has a non-uniform distribution.
- E. Full Scale Comparison: The profiles of thermally induced pressure differentials obtained from the present analytical model for two real buildings have been compared with the results of full scale measurements.

Name/Nom:

Department/Département:

University/Université:

Phone number(Optional)/N° de téléphone (facultatif):

Title of Project/Titre du projet:

ROGER G. WALKER

GEOLOGY

McMASTER

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RESERVOIR GEOMETRY AND PREDICTION OF
SHALLOW MARINE SANDSTONES, ALBERTA

Understanding the origin, location, shape and size of oil and gas reservoirs is clearly of vital importance in the development of those which are already known, and locating possible undiscovered ones. This project was focussed on one particular type of reservoir, characterized by being originally some form of "sand bar" deposited in a marine environment in the seaway that trended roughly north-south through Alberta 90 million years ago. These "sand bars" are tens of kilometres long, a few km wide, and 10-30 m thick. They consist of sand and gravel, now encased below and above by muds which were originally deposited in an offshore marine environment tens of kilometres from postulated shorelines. Thus the problems of the origin of the bars involve how the sand and gravel was transported from the shoreline, and (much more difficult) how it was then concentrated or focussed into the long narrow bars. If these problems could be solved, we would be well on the way to understanding why the bars form, what controls their shape, and why they are located where they are.

Our work has shown that in many cases, the sand, and particularly the gravel, rest on regionally extensive erosion surfaces. The erosion surfaces have a complex topography, which suggests that they were formed at a retreating shoreface. The inferred geological history is therefore 1) deposition of offshore marine muds tens of kilometres from a shoreline; 2) a rapid lowering of relative sea level, resulting in a jump of the shoreline way out into the basin; 3) erosion at this new shoreline, forming an incised shoreface, with gravel supply from incised rivers; and 4) a subsequent rise of sea level, forcing the shoreline back toward its original position, and burying the gravels with marine muds.

We therefore conclude that questions of how gravel moves across the shelf, and how it is focussed into ridges, are the wrong questions to ask. The system appears to be controlled by relative sea level fluctuations rather than sediment transport and focussing, and the gravels represent paleo-shorelines. We have mapped seven sea level fluctuations in the Cardium Formation, which is one of Canada's most important reservoirs; it holds some two billion barrels of oil. We have mapped the shoreline positions of the gravels associated with two of the fluctuations, and we are well on the way to developing a model for the prediction of 1) shorelines at other stratigraphic levels, and 2) the positions of undiscovered parts of already partly-known shorelines. The economic benefit will come from a much better understanding of reservoir distribution, both stratigraphically and spatially, in the Cardium Formation. The ideas developed in this work are potentially applicable to all shallow marine reservoirs, in Alberta, in B.C. and Ontario, and possibly in offshore areas also.

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Name/Nom:

Department/Département:

University/Université:

Phone number(Optional)/N° de téléphone (facultatif):

Title of Project/Titre du projet:

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SEISMIC TOMOGRAPHY

Collaborators: Prof. R. C. Bailey (U. of T. Geophysics, since 84.09)
P. Hurley, (formerly U. of T., now Atomic Energy Canada Ltd.)

BACKGROUND: Controlled source seismology is the most important geophysical method of exploring sedimentary rock formations in which petroleum is sought. Unfortunately, surface seismology is fundamentally limited in its ability to resolve geological features which are very small in relation to their depth, because of the absorption and scattering properties of rocks. Since this limitation can be overcome by putting the seismic source and detectors closer to the feature of interest, and the need to explore small features often arises where some boreholes are already present, there is much interest in developing borehole seismic methods. Two examples of many applications are: 1) in monitoring the complicated progress of in-situ petroleum recovery techniques in tar sands and heavy oil deposits, 2) in delineating the structure of small 'pinnacle reefs' or 'channel sands'; both very important reservoir types in Canada.

This research is an outgrowth of earlier research done in conjunction with the Canadian Nuclear Fuel Waste Management Program where a 'cross hole' seismic method was developed to map structure between a pair of boreholes in crystalline rock. That method was based on seismic transducers that operate in the frequency range 3 to 7 kHz (whereas standard surface-based seismology uses the range 30 to 100 Hz) and on tomographic methods for constructing the image of earth structure from the data.

RESEARCH OBJECTIVES: The underlying purpose of the research was to advance the state of the art in borehole seismology for petroleum and other industrial application. The specific objectives were:- 1) to study how seismic transducers suitable for borehole seismology in sedimentary rock could be designed. They would need to operate at lower frequencies and be substantially more powerful than the ones used in the NFWM Program in crystalline rock. Then prototypes were to be constructed and field tests undertaken wherever possible. Funding of the field surveys was to be obtained elsewhere. 2) to devise better computer algorithms for constructing the tomographic image of rock structure from seismic observations between boreholes. This problem, known as deficient tomography, is fundamentally different and more difficult than the one posed in medical tomography because a part of the needed data and information about the ray paths is unobtainable.

ACCOMPLISHMENTS: All the specific objectives of the program were attained, and the program has demonstrated that the new methodology is practical and very promising. Transducers using ceramic piezo-electric devices for electro mechanical energy conversion and the pseudo-random binary sequence method of coded signal transmission were constructed for use in 5 inch or larger diameter boreholes. The first trial of the system was in summer 1986 using boreholes of Norcen Energy Resources Ltd in the Bodo field near Provost, Alberta where a fireflood procedure is employed to stimulate production of heavy oil from a channel sand at about 740m depth. It was a technically difficult case for a prototype instrument, because one of the holes was at high temperature due to the firing. Excellent seismic signals in the 0.5 to 2.5 kHz range were recorded. The extensive data set is still being analysed using a transmission tomography approach and a reflection analysis method. In this particular case, the tomographic method is the more revealing of geological structure, because an exceptionally thick cement and steel casing in one borehole caused some difficulties with the radiation pattern of one of the transducers. Through the PhD thesis work of Ms. N. Bregman, a very effective algorithm has been created for deficient tomographic analysis.

FUTURE: The development is ongoing under different auspices. Future work will focus more on data analysis than transducer design. Two additional commercial test surveys using the new transducer system have already been carried out by AECL in very different geology.

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Hurley, P., Hatch, D. and West, G., Oral Paper to be given at meeting of the Canadian Society of Exploration Geophysicists, Calgary, May12-14, 1987

ACKNOWLEDGEMENTS: Gratitude is expressed to AECL Ltd for carrying out the field test, and to Norcen Energy Resources Ltd. for making it possible.

REGULATIONS GOVERNING THE USE OF GRANT FUNDS
(Excerpts from the 1986-87 Awards Guide) /

RÈGLEMENTS RÉGISSANT L'UTILISATION DES SUBVENTIONS
(extraits du Guide des subventions 1986-1987)

Description

86. Strategic grants are offered to individuals and groups to assist with the direct operating costs of research projects (including the organization of workshops and seminars) or with the purchase of equipment essential to the pursuit of research projects in the following areas:

- biotechnology
- communications and computers
- energy
- environmental toxicology
- food and agriculture
- industrial materials and processes
- oceans

In addition, through an "open" area, researchers may submit proposals in fields of national concern other than the seven designated areas.

Although individual applications are considered, group applications with a multifaceted approach are encouraged.

Strategic conference grants assist with the organization of conferences in areas of national concern.

Strategic Equipment Grants

104. Strategic equipment grants must only be used to purchase the equipment for which the grant was awarded. If recipients of strategic equipment grants do not require the full amount awarded for this purpose, they must refund the balance to NSERC. A researcher who is not able to purchase the equipment specified, or who wishes to select alternative equipment, must submit a written request to NSERC outlining the reasons for the change. The modified request will be assessed and the grantee will be informed of Council's decision.

NSERC expects beneficiaries of strategic equipment grants to make operating time available to other interested researchers whenever possible.

General Principles

205. Grant funds must be used effectively, economically, and in the best interest of the research supported by the grant. The financial administration of grants and the conditions governing their use are not intended to restrict grantees, but to ensure good accounting and administrative practices.

The administration of NSERC grants is carried out by three parties: the grantee, the university and NSERC.

- The grantee approves expenditures in accordance with NSERC regulations (outlined in the Awards Guide or imposed as a condition of a grant) and with university policies.
- The university administers the grant funds and establishes appropriate policies, controls and systems to ensure that NSERC policies and regulations are followed.
- NSERC defines the conditions under which grant funds may be used, monitors the use of grant funds, and interprets its rules and regulations for the university and grantees.

Description

86. Les subventions thématiques sont accordées à des chercheurs individuels ou à des groupes pour aider à couvrir les frais directs de leurs projets de recherche (y compris l'organisation de colloques et séminaires) ou à acheter des appareils de recherche nécessaires dans les domaines suivants:

- alimentation et agriculture
- biotechnologie
- énergie
- matériaux et procédés industriels
- océans
- télécommunications et informatique
- toxicologie de l'environnement.

Il existe également un thème «ouvert», dans le cadre duquel les chercheurs peuvent soumettre des propositions dans des domaines d'intérêt national autres que les sept thèmes choisis.

Même si les demandes individuelles sont acceptées, le CRSNG encourage les chercheurs à présenter des demandes de groupe à caractère pluridisciplinaire.

Les subventions thématiques pour conférences soutiennent l'organisation de conférences dans des domaines d'intérêt national.

Subventions thématiques d'appareillage

104. Les subventions thématiques d'appareillage ne doivent être utilisées que pour l'achat de l'appareillage pour lequel la subvention a été accordée. On doit retourner au CRSNG tout montant non utilisé à cette fin. Un chercheur qui ne peut acheter l'appareillage décrit dans la demande ou encore qui désire choisir un autre appareil doit faire une demande écrite au CRSNG, en donnant les raisons du changement. Le CRSNG étudiera la demande et informera le bénéficiaire de sa décision.

Le CRSNG s'attend à ce que les bénéficiaires de subvention thématique d'appareillage mettent du temps de fonctionnement de l'appareil à la disposition d'autres chercheurs intéressés, lorsque cela est possible.

Principes généraux

205. Les subventions doivent être utilisées de façon efficace et économique, de manière à favoriser le plus possible la recherche subventionnée. L'administration financière des subventions et les conditions régissant leur utilisation n'imposent au bénéficiaire qu'un minimum de restrictions, mais exigent de bonnes pratiques comptables et administratives.

Les subventions du CRSNG sont administrées par trois parties: le bénéficiaire, l'université et le CRSNG:

- le bénéficiaire approuve les dépenses en se conformant aux règlements du CRSNG (décrits dans le Guide des subventions ou imposés lors de l'octroi de la subvention) et aux politiques de l'université;
- l'université administre les fonds et établit les politiques, les contrôles et les systèmes nécessaires pour assurer le respect des politiques et règlements du CRSNG;
- le CRSNG définit les conditions régissant l'utilisation des fonds, contrôle l'utilisation des fonds et interprète ses règlements pour l'université et les bénéficiaires.

This chapter describes the financial administration of grant funds and outlines the regulations governing their use. Grantees who wish to use their grant funds to purchase resources or services not covered by explicit NSERC guidelines must consult their research grants officer or business officer, prior to committing any NSERC grant funds to such a purchase. If there is no explicit NSERC guideline to answer a question or no university policy covering the subject, the research grants officer or the business officer will seek an appropriate ruling from NSERC.

Fiscal Period

212. NSERC grants are awarded to cover expenditures incurred during a specific period of time termed the fiscal period. The fiscal period for operating grants commences on April 1 of the year of the initial award and may be for one, two or three years. The fiscal period for strategic grants commences on November 1 of the year of the initial award and may be for one, two or three years. If not otherwise specified in published program descriptions or in direct correspondence with grantees, the fiscal period for other awards is one year from the date of the award (see paragraph 213). Upon receipt of a written request, NSERC may extend the fiscal time period of the grant if it is considered to be in the best interest of the research.

Commitments

215. NSERC receives funds for its programs through annual parliamentary appropriations. Thus, all commitments for support beyond the current fiscal year (e.g., second and third instalments of two- and three-year grants) are made subject to the availability of funds. Under no circumstances is NSERC able to accept responsibility for commitments incurred by grantees that exceed the actual funds to their credit in the NSERC Common Grant Account at the university.

Indirect or Overhead Costs

219. The funds provided through NSERC grants in aid of university research must not be used to contribute to the payment of indirect or overhead costs of research.

Payment of Salaries and Stipends

222. NSERC grantees may use their research grant funds to contribute towards the payment of salaries or stipends of qualified people working in their laboratories on a part-time or full-time basis. However, grant funds must not be used to pay any part of the salary or employee benefit plans of the grantee, members of the grantee's immediate family, other staff members of a Canadian university whose status would make them eligible to apply on their own behalf for NSERC grants, or recipients of other direct NSERC support. Grant funds must not be used to employ secretaries, but may be used to pay for typing services for manuscripts and reports.

Ce chapitre décrit l'administration financière des subventions et les règlements en régissant l'utilisation. Le bénéficiaire qui désire utiliser ses fonds pour acheter des ressources ou des services non prévus dans les directives explicites du CRSNG doit consulter le responsable de la recherche ou du service des finances avant d'engager une part quelconque des fonds du CRSNG pour l'achat envisagé. Si les directives du CRSNG ne peuvent répondre à une question, ou s'il n'existe pas de politique universitaire à ce sujet, le responsable de la recherche ou du service des finances s'en remettra au CRSNG pour obtenir une décision appropriée.

Période financière

212. Les subventions du CRSNG couvrent les dépenses engagées pendant une période désignée période comptable. La période comptable des subventions pour dépenses courantes débute le 1^{er} avril et peut durer un, deux ou trois ans. La période comptable des subventions thématiques débute le 1^{er} novembre de l'année où la subvention est accordée et peut durer un, deux ou trois ans. À moins d'indication contraire dans la description du programme ou dans les conditions d'octroi, la période comptable des autres subventions dure un an à compter de la date d'octroi (voir l'article 213). Sur réception d'une demande écrite, le CRSNG peut prolonger la période comptable d'une subvention s'il juge que c'est dans le meilleur intérêt de la recherche.

Engagements

215. Le CRSNG reçoit du gouvernement des fonds pour ses programmes de subventions et bourses sous forme de crédits parlementaires annuels. Le CRSNG prend donc des engagements pour les années financières postérieures à l'année courante (p. ex. les deuxième et troisième versements de subventions de deux ou de trois ans) sous réserve de la disponibilité des fonds. Le CRSNG ne peut donc accepter aucune responsabilité à l'égard d'engagements financiers qui dépassent les fonds disponibles dans le compte commun des subventions à l'université.

Frais indirects ou généraux

219. Les bénéficiaires ne doivent pas utiliser les fonds octroyés par le CRSNG dans le cadre de ses programmes de subventions pour payer des frais indirects ou généraux de recherche.

Salaires et traitements

222. Les bénéficiaires de subvention du CRSNG peuvent utiliser leur subvention de recherche pour payer les salaires ou traitements de personnes qualifiées travaillant à temps complet ou partiel dans leurs laboratoires. Cependant, ils ne peuvent s'en servir pour payer une partie du salaire ou les avantages sociaux du bénéficiaire, des membres de sa famille immédiate, des membres du personnel d'une université admissibles aux subventions du CRSNG ou encore des bénéficiaires d'autre forme d'aide directe du CRSNG. Ils ne peuvent l'utiliser pour employer une secrétaire, mais peuvent s'en servir pour payer les services de dactylographie pour les manuscrits et les rapports.

Persons in one of the following three categories may be employed under a grant:

- assistants employed to help grantees carry out their research (research associates, research assistants, undergraduate students, programmers, technicians and other technical and non-professional assistants);
- postgraduate students and postdoctoral fellows receiving a stipend to work under the grantee's supervision or as collaborators to the grantee; such persons may not, however, be paid from infrastructure grants;
- visiting scientists receiving transportation, meal and accommodation expenses and stipends (if they are not themselves eligible to apply for NSERC grants) when invited by grantees to collaborate with them.

Summary of Salaries and Stipends from Grants

Assistants

- subject to university policies

Graduate students

- per annum: \$10,560
- per month: \$ 880

Purchase of Equipment and Other Materiel

237. When purchasing equipment and materiel, grantees must follow university procedures related to purchasing. Grantees must explore the possibility of purchasing equipment manufactured in Canada. Refer to paragraph 249 concerning the purchase of powered vehicles.

Ownership of Equipment and Other Materiel

238. All equipment and materiel (including specialized books and publications, small assets such as cameras, small calculators, binoculars, tents, skis, etc.) purchased with NSERC grant funds belong to the university and not to the individual grantee.

When a researcher is moving to another Canadian university and wishes to move equipment or other materiel purchased with NSERC grant funds, Council encourages the university to accede to such a request provided the equipment is not necessary for the research activities of other researchers at that university. Assets so moved will belong to the new university.

Computing Costs

241. Grant funds may be used towards payment of charges for machine time, programming services and other related expenses essential to the conduct of the research for which the grant was awarded.

Les personnes appartenant à l'une ou l'autre des catégories suivantes peuvent être rémunérées à même une subvention:

- adjoints engagés pour aider le bénéficiaire à réaliser son projet (attachés, adjoints de recherche, étudiants de 1^{er} cycle, programmeurs, techniciens et autres adjoints techniques ou non professionnels);
- étudiants de 2^e ou 3^e cycle et stagiaires postdoctoraux recevant un traitement pour travailler sous la direction du bénéficiaire ou en collaboration avec lui; ces derniers ne peuvent toutefois pas être rémunérés à même une subvention d'infrastructure;
- scientifiques invités recevant des frais de déplacement, de repas et de logement et un traitement (s'ils ne sont pas eux-mêmes admissibles aux subventions du CRSNG) lorsqu'ils sont invités par le bénéficiaire à collaborer avec lui.

Résumé des salaires et traitements payés à même les subventions

Adjoints

- traitements assujettis aux politiques de l'université

Étudiants (2^e et 3^e cycles)

- par an: 10 560\$
- par mois: 880\$

Achat d'appareillage et de fournitures

237. L'acquisition d'appareillage et de fournitures doit respecter les politiques d'achat de l'université. Les bénéficiaires doivent étudier la possibilité d'acheter des appareils fabriqués au Canada. Consulter l'article 249 pour les règlements régissant l'achat de véhicules motorisés.

Propriété de l'appareillage et d'autres biens

238. Tout appareillage et autre matériel (y compris, les livres et publications spécialisés, appareils-photo, calculatrices, jumelles, tentes, skis, etc.), achetés grâce à une subvention du CRSNG appartiennent à l'université, et non au bénéficiaire.

Lorsqu'un chercheur déménage dans une autre université au Canada et qu'il désire apporter avec lui les appareils ou autres biens achetés avec l'aide financière du CRSNG, le Conseil encourage l'université à accéder à sa requête si les appareils ne sont pas nécessaires aux travaux d'autres chercheurs de l'université. Les biens ainsi déménagés appartiendront à la nouvelle université.

Frais d'ordinateur

241. Les subventions du CRSNG peuvent servir à payer le temps-machine, les frais de programmation et autres frais connexes lorsque ces dépenses sont essentielles à la poursuite de la recherche pour laquelle la subvention a été accordée.

Patents

243. NSERC grantees are encouraged to seek patent protection for their inventions or developments, particularly in such a way that will benefit Canada. One method of accomplishing this is to consult with and use the services of Canadian Patents and Development Limited (CPDL). Many universities have an agreement with CPDL to achieve this end.

Publications

244. Grant funds may be used to purchase certain specialized publications not normally obtainable through the university library and that are essential to the research supported by Council. These may include special tables, catalogues of functions, published data, specialized journals and like material. Such publications belong to the university.

245. Grant funds may be used towards costs involved in the preparation of manuscripts, whether for articles in research journals or books, and towards the payment of page charges for publication in scientific journals. Grant funds must not, however, be used to pay for printing costs involved in the publication of a book.

246. Grantees are encouraged, whenever possible, to publish the results of their NSERC supported research in Canadian journals, including not only the Canadian Journals of Research published by the National Research Council, but other Canadian scientific and technical publications as well.

Acknowledgement of NSERC Support

247. In any publication arising from research supported by Council grants, acknowledgement of NSERC assistance is expected.

Travel Expenses

248. Grant funds may be used to pay transportation, accommodation and meal expenses incurred during brief trips away from the grantee's university when these are essential to the research funded through the grant. The expenses may be incurred by grantees or by persons working with or for the grantees. Such trips include field trips (e.g., to collect specimens or samples or to use facilities located elsewhere), trips to consult with colleagues and attendance at conferences, meetings, symposia, etc. Transportation to and from the location(s) of sabbatical leave and personal living expenses while at the place(s) of sabbatical leave are not allowable expenses from operating grants. However, field trips and conference travel during the period of sabbatical leave are allowable as specified above.

Research travel associated with leave in excess of three months is not normally considered a brief trip, but under certain circumstances may be supported through NSERC grants:

Brevets

243. Les bénéficiaires de subvention du CRSNG auraient avantage à protéger leurs inventions ou leurs découvertes, particulièrement de façon à en faire bénéficier le Canada. Ils peuvent, à cette fin, consulter la Société canadienne des brevets et d'exploitation Limitée (SCBE) et recourir à ses services. Plusieurs universités ont conclu à cet effet un accord avec cette société.

Publications

244. Les subventions peuvent être utilisées pour l'achat de publications spéciales, comme des tables de données, des catalogues de fonctions mathématiques, des revues spécialisées et autres renseignements du genre qui ne peuvent être obtenus dans les bibliothèques des universités et qui sont nécessaires à la bonne marche des travaux de recherche subventionnés par le Conseil. Ces publications appartiennent à l'université.

245. On peut se servir des subventions pour payer les frais engagés lors de la préparation des manuscrits, qu'il s'agisse d'articles dans des revues scientifiques ou de livres, et pour payer les frais de publication dans des revues scientifiques. On ne peut toutefois se servir de ces fonds pour payer les frais d'impression qu'entraîne la publication d'un livre.

246. On encourage les bénéficiaires de subventions à publier les résultats de leur recherche subventionnée par le CRSNG dans des journaux canadiens, si possible. Il peut s'agir non seulement des journaux canadiens de recherche publiés par le CNRC, mais aussi d'autres publications scientifiques et techniques canadiennes.

Mention de l'aide du CRSNG

247. Le CRSNG s'attend à ce que les bénéficiaires mentionnent l'aide reçue dans toute publication réalisée grâce à une subvention du Conseil.

Frais de déplacement

248. Les subventions du CRSNG peuvent servir à couvrir les frais de transport, de logement et de repas engagés lors de brefs voyages à l'extérieur de l'université, lorsque ces déplacements sont essentiels à la conduite des travaux de recherche subventionnés. Il peut s'agir des dépenses du bénéficiaire ou de ses adjoints. Ces déplacements incluent les voyages vers les lieux d'expérience (cueillette d'échantillons ou utilisation d'installations de recherche) et pour consulter des collègues ou assister à des conférences, congrès, symposiums, etc. Les frais de déplacement (aller retour) du chercheur vers le lieu de son congé sabbatique et ses frais personnels de séjour au cours de ce congé ne sont pas admissibles. Toutefois, les voyages effectués au cours de ce même congé, vers les lieux d'expérience ou pour assister à des conférences sont admissibles, tel qu'il est précisé ci-dessus.

Tout déplacement lié à des activités de recherche et effectué au cours d'un congé de plus de trois mois n'est normalement pas considéré comme un voyage de courte durée; toutefois, il est parfois possible, dans des circonstances spéciales, d'en assurer le financement à l'aide des subventions du CRSNG:

- To spend research leave outside Canada — candidates must apply through the international programs of NSERC.
- To spend research leave within Canada for 3-6 months — operating, strategic and university-industry grant recipients must apply to NSERC for permission to use research grant funds for transportation expenses only.
- To pursue an extended field trip or to visit a foreign facility in excess of 3 months — permission must be granted by NSERC in writing.

Claims for travel expenses chargeable against NSERC grants must conform to the standard procedures and policies of each grantee's university, and a university has the right not to authorize an expenditure proposed by the grantee if such an expenditure contravenes university policies and/or any NSERC regulations. See paragraph 211 for submission of travel claims.

Grant funds must not be used to reimburse any travel expenditures for members of the grantee's immediate family.

Powered Vehicles

249. Recipients of NSERC grants may purchase a powered vehicle when essential to the research funded through the grant. However, prior university approval is required. By approving the purchase, the university accepts responsibility to provide insurance and any licence required and to register the vehicle in the name of the university. Grantees may also use their grant funds to pay for the long-term lease or short-term rental of such vehicles essential to the research funded through the grant. Grantees who wish to lease a powered vehicle on a long-term basis require the prior authority of the university. This procedure is similar to that required for an outright purchase.

Costs of short-term rentals of vehicles will be recorded on travel claims with other expenses of the field trips, etc.

If powered vehicles purchased through the grant or leased on a long-term basis through the grant are kept at a location other than the university, grantees must be prepared to certify that the vehicle will be used for research purposes only.

Organization of Conferences and Workshops

250. Grant funds must not be used to cover the cost of holding a conference or symposium. Canadian university staff members wishing to obtain funds to support the cost of transportation, meal, and accommodation expenses of guest speakers should apply for a conference grant (see paragraphs 157 to 165). Strategic grant funds may be used for the organization of workshops, provided the request was included in the application. In addition, NSERC is prepared to provide funding for the organization of university-industry workshops (paragraphs 129 to 131) or of other workshops (paragraph 166). Regulations governing these new programs will be stated in the conditions of the award. Council does not have a program of support for attendance at conferences; however, operating grant funds may be used for this purpose (paragraph 248).

- En ce qui touche les congés liés à des activités de recherche à l'extérieur du Canada — les intéressés doivent présenter une demande dans le cadre des programmes internationaux du CRSNG.
- En ce qui touche les congés liés à des activités de recherche au Canada — les bénéficiaires de subventions pour dépenses courantes, de subventions thématiques et du programme conjoint universités-industrie doivent demander au CRSNG la permission d'utiliser leur subvention pour payer leurs frais de déplacement seulement.
- En ce qui touche la prolongation de plus de trois mois d'une visite vers les lieux d'expérience et à une installation à l'étranger, les bénéficiaires doivent en recevoir la permission écrite du CRSNG.

Les frais de déplacement imputables aux subventions du CRSNG doivent être conformes aux procédures et politiques courantes de l'université de chaque bénéficiaire; cette dernière peut refuser les dépenses proposées par le bénéficiaire si elles sont contraire à ses politiques ou aux règlements du CRSNG. Voir l'article 211 pour la présentation des demandes de frais de déplacement.

Les subventions du CRSNG ne doivent pas servir à payer les dépenses de voyage des membres de la famille immédiate du bénéficiaire.

Véhicules motorisés

249. Les bénéficiaires de subventions du CRSNG peuvent acheter un véhicule motorisé lorsque ce dernier est essentiel à la conduite des travaux de recherche subventionnés. Les bénéficiaires doivent cependant obtenir l'approbation de l'université avant d'acheter tout véhicule motorisé. En approuvant l'achat, l'université accepte de fournir les assurances et les permis nécessaires et d'enregistrer le véhicule à son nom. Les bénéficiaires peuvent également utiliser leurs subventions pour payer les frais de location à long terme ou à court terme de tels véhicules lorsqu'ils sont essentiels à la conduite des travaux de recherche subventionnés. Les bénéficiaires qui désirent louer un véhicule motorisé à long terme doivent obtenir l'autorisation préalable de l'université tout comme s'ils désiraient en faire l'achat pur et simple.

Les frais de location à court terme de véhicules seront indiqués sur les demandes de frais de déplacement avec les autres dépenses de voyage vers les lieux d'expérience, etc.

Si les véhicules motorisés achetés ou loués à long terme avec les subventions du CRSNG sont gardés ailleurs qu'à l'université, les bénéficiaires doivent être prêts à certifier que le véhicule servira exclusivement aux fins de la recherche.

Organisation de conférences et colloques

250. Il est interdit de se servir des subventions pour payer les frais d'organisation de conférences. Si un membre du corps enseignant d'une université canadienne désire obtenir des fonds pour payer les frais de déplacement, de repas et de logement de conférenciers invités, il doit demander une subvention pour conférences (voir les articles 157 à 165). On peut se servir des subventions de recherche thématique pour organiser un colloque, à condition d'en avoir fait la demande. De plus, le CRSNG est prêt à subventionner des colloques dans le cadre de son programme conjoint universités-industrie (articles 129 à 131) ou dans d'autres circonstances (article 166). Les règlements s'appliquant à ces nouveaux programmes seront énoncés dans les conditions d'octroi. Le CRSNG n'a pas de programme de subvention pour venir en aide aux chercheurs qui participent à des conférences; les subventions de recherche peuvent cependant être utilisées à cette fin (voir l'article 248).